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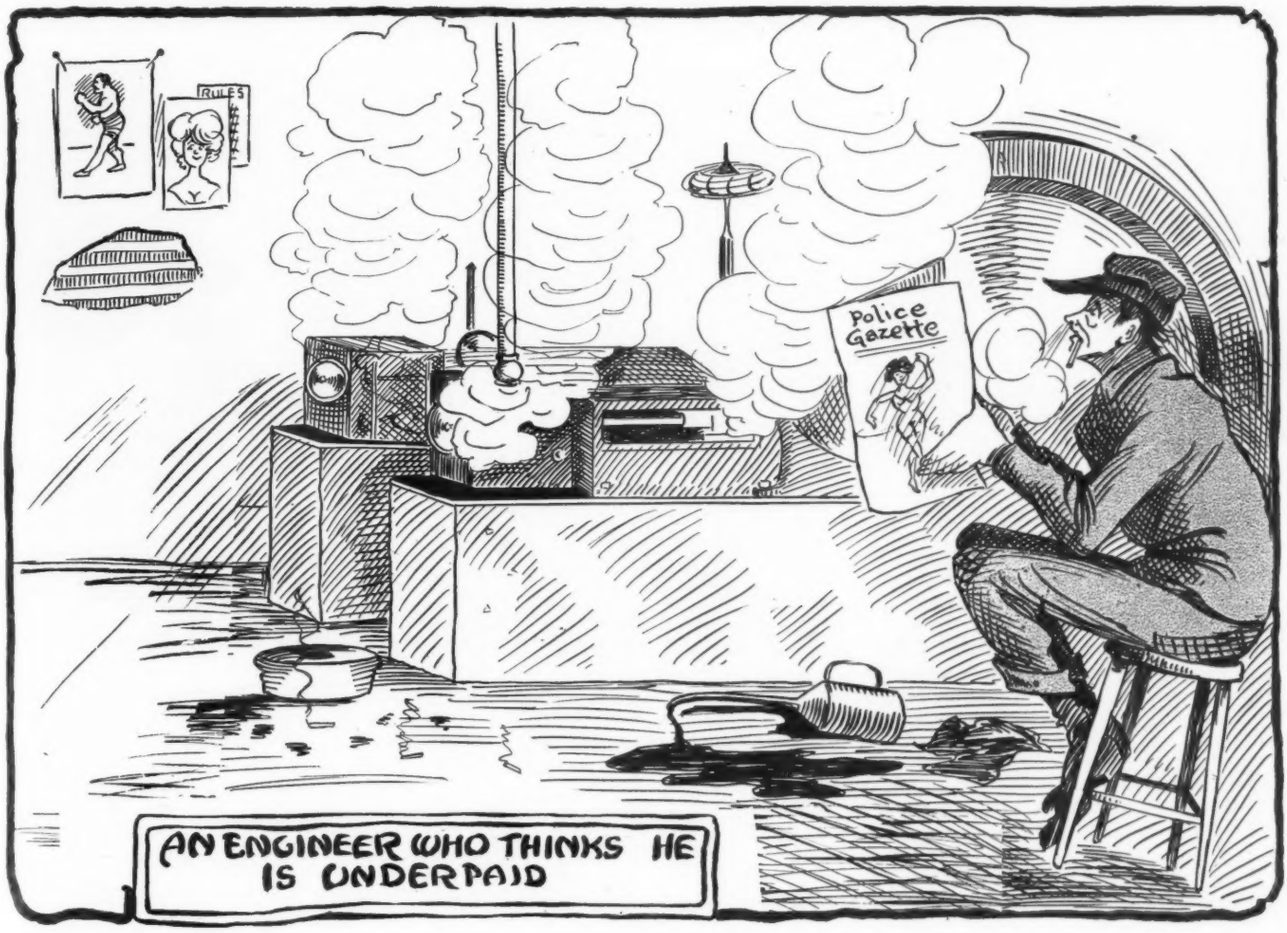
"To Earn More, Learn More!"



A "POWER" READER'S CONCEPTION OF AN "ENGINEER" WHO THINKS HE IS UNDERPAID

Turbo Pumps in German Water Works

By Alfred Gradenwitz

A description of the first German Water Works equipped with turbo pumps having a combined capacity of 7,062,960 cu. ft. of water per 24 hr.

The managers of the Charlottenburg Water Works were the first in Germany to realize the importance of turbo-pumps for water-work service and two years ago they installed a 1000-hp. unit with a rating of 95,348 cu.ft. per hour; three additional sets of the same size will shortly be installed.

Whereas the turbo-pumps in this case only form an extension to an existing plant equipped with plunger pumps, the provincial water-works at Inheiden, are the first German water-works designed from the beginning for exclusive turbo-pump service.

A view of the turbine-pump room is shown in Fig. 1. The principal advantages of turbo-pump service lie in the uniform strain on the pumping plant and the attainment of a practically constant pressure in the main piping. In the pressure piping, which is about 26.7 miles long, there are alternate rises and falls throughout its length. If a pressure valve should be incorrectly closed there is, in the case of plunger pumps, a danger of a sudden rise in pressure, resulting in a bursted pipe. This could not occur with centrifugal pumps, and the same applies to starting the plant.

The economy of a turbo-pump installation is not inferior to that of a water-works operated by plunger pumps. Furthermore, in spite of the somewhat higher coal bill with centrifugal pumps, the lower cost of installation, the small amount of wear, the low expenses for attendance and oil consumption represent such large savings in the sinking funds and running costs not only to cover the extra fuel cost but, under favorable conditions, even allow a considerable margin.

The Inheiden provincial water-works was installed to utilize some of the numerous springs of Upper Hesse and supply water to several small districts, principally to the town of Frankfort, whose rapid development has made it necessary to obtain its drinking water from a greater distance. The pumping station is in the center of the spring district, between Hungen and Trais-Horloff. Those acquainted only with the engine rooms of plunger-pump water-works will hardly realize that in so small a building as much as 7,062,960 cu.ft. of water daily are pumped to a height of about 262 ft.

In its general layout the engine room shows many unusual features. In place of the movement of cranks, reciprocating rods and rotating flywheels in the spacious hall are two low inclosed machines, cylindrical in form, on which, at first glance, only the slowly rotating governor shows that they are working at a high speed.

One attendant supervises the running of the machines; the quietness with which he goes about his work reflects the simplicity of the easily controlled service and its reliability.

One of the two sets runs day and night without interruption for one week when it is relieved by the other which has been kept ready for service as a stand-by unit. Later, when long experience has convinced the management of the absolute reliability of the turbo-pumping service, the working period for each machine will be extended to at least four times its present length.

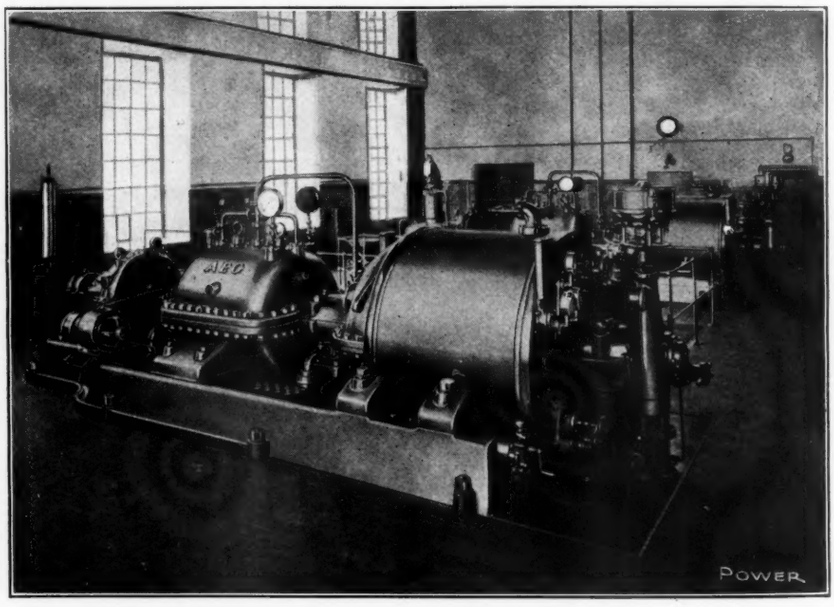


FIG. 1. VIEW OF THE INHEIDEN TURBO-PUMPING STATION

Each of the two units consists of a steam turbine, the shaft of which is directly coupled to the centrifugal pump mounted on the same base. On the other side of the pump, coupled to the main shaft, is the rotary wet-air pump, but the vertical condenser pump mounted on the floor of the cellar is driven from the main shaft by a worm gear. Besides the large centrifugal pump, a small auxiliary pump with an output of 5½ gal. per second is mounted at the end of the horizontal main shaft, which receives water from the pressure chamber of the large pump, and after a later extension of the works, will be used to pump water 410 ft. to a highly situated district. As an ample supply of excellent cooling water can be obtained at a pressure of about 4-m from the Riedbach, which flows under the station, it was not necessary to install a special circulating pump.

A common base-plate for the turbine and the pumps of great strength insures the necessary stability of the entire machine set and contributes toward its steady running.

All bearing parts are supplied with oil by means of an oil-pressure pump, consisting of two toothed wheels gearing with one another and fitting exactly into the wheel case. The absence of valves, pistons, springs, etc., render the oil pump immune from breakdown. It is driven by the governor spindle to which one of the wheels is keyed. During the starting period, when the pump speed is too low to give the necessary quantity of oil at a sufficient pressure, a small oil pump for hand operation is provided. The temperature of the oil in the separate bearings exceeds 120 deg. F. The oil from the bearings is cooled in the oil cooler, from which it is again drawn by the pump, thus the quantity of the lubricating material required is very limited and requires renewing only at long intervals.

The steam turbines work with a steam pressure of 170 lb. and a temperature of 660 deg. F. measured at the inlet nozzle. The speed is 2800-3000 r.p.m. They are built with high- and low-pressure stages. The turbine casing is divided in the center; after raising the upper

part, the wheel vanes and the guide blades are exposed, and overhauling can be done without much trouble. An undivided cover closes the turbine on the front side, on which the regulator and the inlet nozzles are placed.

The regulating mechanism is of the standard type. The vertical-spring centrifugal governor is driven through a worm gearing from the turbine shaft, and by the movement of the governor sleeve actuates a small relay valve which either admits oil to a pressure cylinder or allows it to flow out. The piston of this cylinder is rigidly connected with the actual regulating valve, which simultaneously controls the quantity and pressure of the live steam coming from the boiler. In addition to this automatic regulation, the most favorable admission for the moment may be obtained by opening or closing separate inlet nozzles by hand.

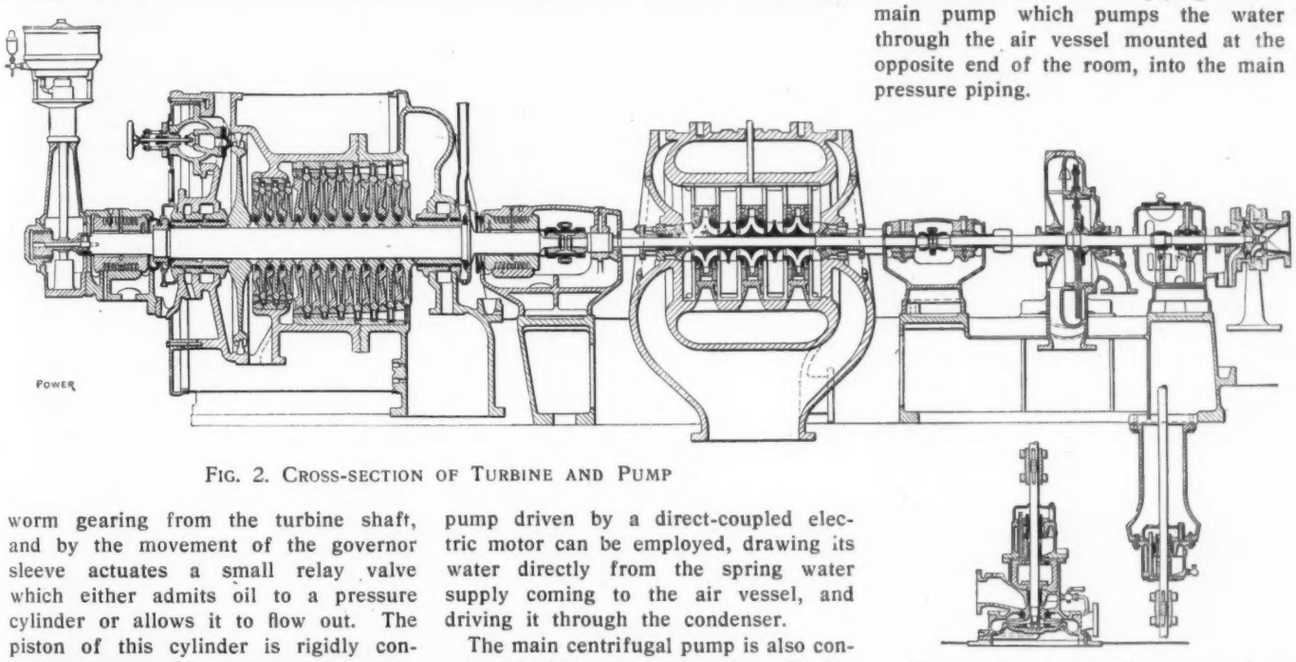


FIG. 2. CROSS-SECTION OF TURBINE AND PUMP

The surface condenser is installed below the turbine in the machine cellar through which flows the Riedbach. In consequence of the extensive cooling surface and the large quantity of cooling water available, the condensation is ample. Under normal working conditions the cooling water flows off again slightly warmed, and is constantly controlled by a thermometer having an electric contact device. If for any reason the temperature exceeds a given limit, an alarm bell indicates the fact to the attendant. If there is insufficient water in the Riedbach, or should it be otherwise impossible to obtain the cooling water from this source, a centrifugal pump driven by a direct-coupled electric motor can be employed, drawing its water directly from the spring water supply coming to the air vessel, and driving it through the condenser.

The main centrifugal pump is also constructed with a two-part casing. During the first period of service the pump, with its two impellers working in parallel, raises water to a height of 263 ft.; in the second period the auxiliary centrifugal pump will probably be employed, and will pump against an additional head of about 148 ft. Later, at a third period, in which the quantity of water to be delivered must be increased about one-third, the main pump will work against a head of 328 ft., while the auxiliary pump will deal with a head of but 82 ft., in order to attain the necessary head of 410 ft. The higher output of the third period can be had by mounting a third impeller on the main pump, which can be accomplished without altering the shaft or casing. A sectional drawing of the pump set is shown in Fig. 2.

From the six springs from which water is taken at the present time, a collecting pipe leads the drinking water to the air vessels installed inside the building and connected to the section piping of the main pump which pumps the water through the air vessel mounted at the opposite end of the room, into the main pressure piping.

On starting the machine, the air is sucked from the air vessel and the main pump by means of a steam ejector from which the water level of the pump can be accurately observed. When the machine is running, the air collecting in the air vessel can be drawn off by means of a hydraulic air pump, or it can be removed by a water ejector fed from the pressure piping, or from a compressor. The latter also serves to admit air to the air-pressure vessel when the water level glass shows that the water is too high. Directly in front of the air-pressure vessel, between the latter and the pump stop valves, a rigidly anchored nonreturn valve

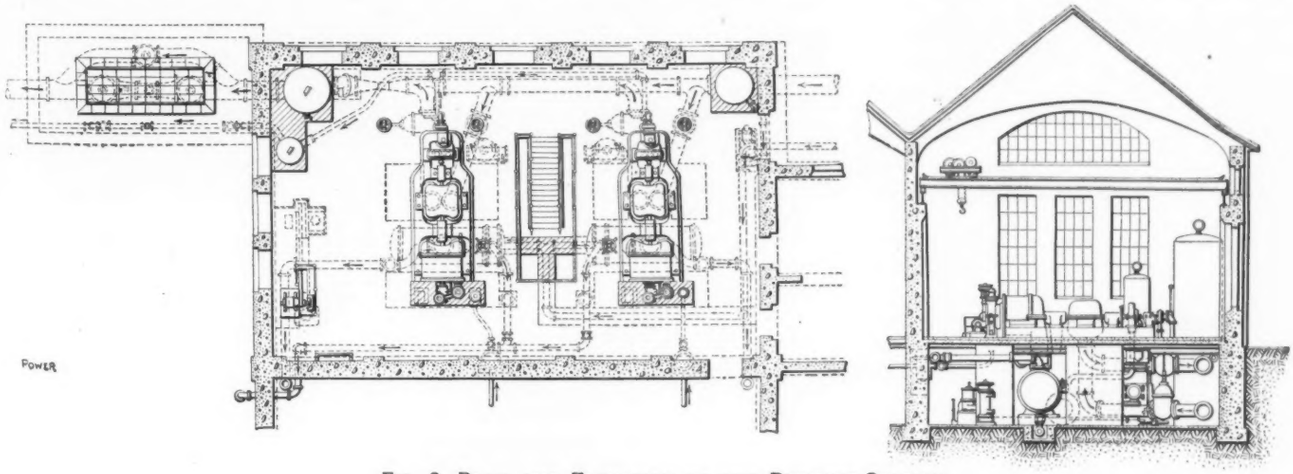


FIG. 3. PLAN AND ELEVATION OF THE PUMPING STATION

is placed, provided with separate valve flaps to protect the pumps against water-hammer in the mains.

In front of this nonreturn valve a measuring nozzle constructed on the venturi system is inserted, is connected with a differential manometer mounted on the machine-room wall, from the scale of which it is possible to ascertain the exact quantity of water pumped. When taking readings regularly at given intervals, the total quantity pumped can also be thus controlled. In addition, this is carried out automatically by a meter provided with a clockwork mechanism and a remote-recording device mounted on a special measuring compartment behind the air-pressure vessel. A special system of piping with the necessary change-over valves allows the meter to be cut out or extended at any time. A second smaller air-pressure vessel having a meter with its system of piping connected to it, intended for use later with the auxiliary centrifugal pump, is already provided with the necessary connecting piping.

The compressor is driven by a belt from a small, vertical steam engine which also drives a continuous-current generator. The latter supplies the current for the exterior and interior lighting of the pumping station, and also supplies the motors operating the stokers, economizer and the repair shop. As a rule, however, the generator only takes over this work in the evening when it has the lighting load, or when the motor for the reserve cooling-water plant is in service. During the day the motors are run from the small dynamo on the base-plate of each turbine near the air pump, and belt driven from the main shaft.

Fig. 3 shows the entire plant in plan and elevation.

In the Inheiden Water Works all the advantages of the turbo-pump system are combined; the low maintenance and running costs, the small space occupied, the easily supervised service and great reliability in working.

Data necessary for estimating the economy of the service are constantly noted by self-recording instruments, as steam and feed-water meters, recording manometers, etc., and are controlled by the management. The boiler plant, the coal-conveying plant and the arrangements for an efficient utilization of the fuel are of the most perfect obtainable, and great care has been given to designing the building and its annexes.

The installation is worthy of imitation by municipal communities, and it may also be regarded as a model installation technically.

One of the recent purchases made at Cairo, Egypt, by the Sultan of Lahej, is an electric dynamo for generating light in his palace at Lahej. An electrical engineer has been engaged to look after the plant.

Massachusetts Workmen's Compensation Act

Engineers employed in the hazardous trades and their employers will watch with interest the working of the new Massachusetts law regulating and fixing the compensation for accidental injuries, which went into effect July 1. Its basic principle is that when accidents occur during industrial labor, the expense of the employee's injuries should be charged, as is that of accidents to machinery, to the cost of production.

The common-law defenses—that the employee was negligent, that he had assumed the risk of injury, or that the injury was caused by a fellow employee's negligence—are abolished by the act as defenses for those employers who refuse to come under the protection of the new law, unless the employee also refuses to accept the act. In this case the employer continues to be protected by the common law and the injured workman must seek damages in the courts as heretofore.

If the employee comes under the act, and the employer elects not to accept, which requires a written notice to the board to that effect, the employee can proceed against the employer and the foregoing three defenses will not be allowed the employer; the sole question to be decided by the court will be the employer's negligence.

That the act shall be of advantage to both employer and employee, the compensation for each kind of injury, so far as possible, is definitely stated, and is based on the probable loss of earnings of the party injured.

For minor injuries, medical and hospital services must be provided by the employer for not over two weeks. If the injury is serious, compensation must be paid, based on half the weekly wage, but not to exceed $10 nor less than $4 per week, beginning the first day of the second week and continuing during the disability not exceeding 500 weeks, or a total compensation of $3000.

If death results from injury, the $3000 is to be paid to the deceased's dependents during 300 weeks, as the employer or insurance company may decide. Additional payments shall be made for loss of both hands or feet, or one hand and one foot, or one-tenth reduction of the normal vision in both eyes with glasses, payments to continue for 100 weeks in addition to the disability compensation; loss of either hand or either foot, or one-tenth reduction of normal vision in either eye with glasses; the additional payments continue for 50 weeks; for the loss of two or more fingers, including thumbs, the period of additional compensation is fixed at 25 weeks. For minor injuries additional payments continue for 12 weeks. The employer is fined $50 for each offense or failure to report to the board, within 48 hours, each accident to an employee.

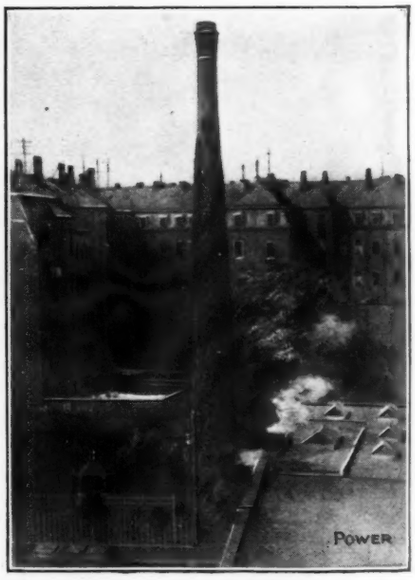
This law was urged by employers and employees, the employer desiring a reasonable and specific compensation for injuries to employees and thus avoiding law suits, and the employee desiring protection for himself and dependents when he may be incapacitated by injury.

The board has charge of the administration of the act, the interpretation of the new law, the supervision of compensation agreements and the settlement of all controversies between employers and employees. There are five members and a secretary, appointed by the governor. The board headquarters is in the Pemberton Building, Boston, where information may be had.

An Ornamental Chimney

By Dr. Robert Grimshaw

The average factory chimney is not decorative to any landscape, but its appearance may be improved by allowing creeping vines to cover its bare bricks



An Ornamental Chimney

and mortar. In Dresden, once famous only for its art collections and beautiful surroundings, factory chimneys are now numerous, except in the residential quarters; and have done much to disfigure the city.

In some instances, however, and especially where the plants are in courts behind flat-houses (as in the built-up sections) the owners have made the chimneys less hideous by the means above mentioned. The illustration is taken from the upper story of a flat building, and shows the result.

The Illinois Central Ry. has adopted a plan for the electrification of its line in Chicago; the work to be done within the next five years.

The Corliss Engine—A Lecture

By F. R. Low

Corliss did not invent the automatic cutoff nor the four-valve engine. What, then, is the distinctive feature of a Corliss engine?

The lecture tells of what Corliss improvements really consisted and gives directions for setting the valves of his engine.

I suppose there is not a man in the room who would balk at the question, "What is a Corliss engine?" and who would not be surprised when he found how difficult it is to tell. Corliss certainly did not invent the four-valve engine. All the earlier engines had separate steam and exhaust valves, and it was only a later stroke of genius which combined the functions of all four in the ingeniously simple D-slide valve. Corliss did not invent the cutoff, as many suppose. Steam was cut off and used expansively in the engines of Watt. He did not originate the idea of regulating the speed of the engine by varying the cutoff instead of the initial pressure. In one of his own patent applications he refers to a description in Tredgold's "Treatise on the Steam Engine," of an engine which had poppet valves operated by a cam under the control of the governor; to the description by the French author Armengaud, in his "Publication Industrielle," of another engine in which the regulator acted upon a cam which was made to act upon the valve rods so as to close the valves at varying portions of the stroke; and to a description in *The Practical Mechanic and Engineers' Magazine*, a Scotch publication, in 1846 of an engine with a riding cutoff under the control of the governor. These were all prior to Corliss' first patent, which was not issued until 1849.

Zachariah Allen, an engineer of Providence, patented, in 1834, an arrangement whereby the governor valve, instead of being opened more or less and throttling the pressure according to the load, was opened fully at the commencement of the stroke by a lever resting on a cam on the main shaft. The cam was wedge-shaped, and when the bearing end of the lever rested on its narrow end the valve was held open but a short fraction of the stroke. When it was changed to the wide end of the cam the valve was held open for the greater part of the stroke, and its position upon the cam was controlled by the governor. An engine of this type was put into practical operation at the Wadsworth Steam Engine Works at Providence, in 1834.

In 1842, F. E. Sickels patented the Sickels valve, so well known in marine practice. Here the *main* valve is made to do the cutting off by means of a trip-motion, the shock of the closing poppet valve being taken up by means of "cushions of yielding water," whence comes the term "dashpot," still applied to the modern substitute, which has nothing to suggest a dash about it.

Sickels was a marine engineer, and marine engines use no governor. He made his detachable or trip cutoff adjustable by hand, so that the speed could be controlled by shortening the cutoff instead of by throttling, but unfortunately for himself, though luckily for Corliss, he did not suggest in his patent specifications that this might be done automatically by the governor.

Under date of February 3, 1870, Zachariah Allen wrote to Mr. Corliss a remonstrance against his acceptance of the Rumford medal which had been awarded to him by the American Academy of Arts and Sciences for inventions that originated "the abolition of the throttle valve of the steam engine and for placing the induction valves under the control of the governor." In the course of his letter he describes a combination of his own and Sickels' invention as follows:

> "You have frequently seen the large steam engine in the print works constructed by my brother, Philip Allen, near your office in Providence, and now under my charge, and are aware that it has been operated by the use of a ball regulator applied to produce a variable and detachable cutoff movement, as described in my patent and in the improvements patented by Mr. Sickels independently of the use of a throttle valve, and of any of your claims for steam-engine patents.
>
> "This steam engine has been in operation during the whole term of 14 years of your outstanding patent claims, and is now operating excellently well, with an economy of coal, and a perfection of effective power, as indicated by diagrams, unsurpassed, as I believe, by any engine of your construction."

In the course of the same letter he says further:

> "While you have originated a rotary valve, with new and peculiar devices for producing with that valve the same results which had been previously effected by the above described inventions of your predecessors, you must certainly feel that you are not the first person who promulgated or accomplished these inventions, nor the first to reduce them to practical use."

Ah! the Corliss valve, known as such all over the world. Now we have got to something essentially Corliss. But his claim even to this is not undisputed. In the early days of my connection with POWER I called upon William Wright, at Newburg, one day when the old gentleman was in a reminiscent mood. We talked of Corliss and of the time when Wright was superintendent of his shop, and the old man went to the safe, rummaged through some drawers and produced from between the leaves of an old notebook a time-worn sketch, yellow with age, and proceeded to tell me this story of the inception of the Corliss valve.

A few engines had been built in which the releasing gear invented by Mr. Corliss had been applied to different forms of slide valve with more or less satisfaction, mostly less, so far as the practical working of the valve was concerned. Meanwhile the efforts of the inventor were bent in the direction of a valve better adapted to the requirements of his cutoff, which had demonstrated its superiority as a means of regulation.

At this time an order had been taker for the Eddy Street Foundry, of which the father of William A. Harris, of the engine company of the same name, was superintendent. The frame and connec-

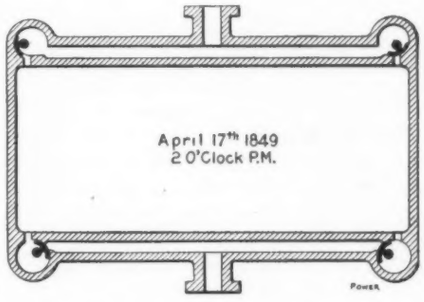


FIG. 1. MR. WRIGHT'S SKETCH

tions of the beam engine had been made, but the cylinder had been allowed to wait, pending the evolution of an improved valve. Mr. Harris became urgent in his demands for delivery, and on April 17, 1849, Mr. Wright approached Mr. Corliss with the question of the delayed cylinder. In the course of the conversation which followed Mr. Wright took up a piece of paper and made the sketch shown in Fig. 1. The suggestion was greeted by Mr. Corliss with the statement that if he could not have something better than that he would not have anything. Nothing better seems to have offered, however, for thousands of engines have been built in this way, and the appliance shown is universally known as the Corliss valve.

This sketch has recently been presented to me, along with other mementos of her father, by Mr. Wright's daughter, and I am thus able to show the original, creased and worn, held together with tracing cloth, and bearing upon its back, almost undecipherable, the date of its alleged production. I do not know

that any patent was ever taken out upon this valve. It does not seem to have figured in the long and bitter litigation in which the Corliss patents were involved and it was only after the death of Mr. Corliss that this sketch was brought to light, notwithstanding Mr. Wright was an opponent to Corliss in some of the patent suits.

It is probable, if the authenticity of the sketch is admitted, that Corliss found possibilities in it upon examination that failed to impress him at first sight, and that both considered it a legitimate contribution to the development of the engine by a man whose brains, as well as his hands, were in the paid employ of the company.

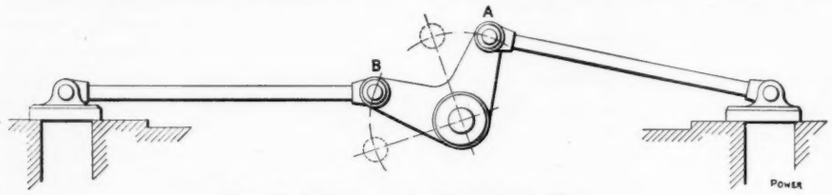


FIG. 2. METHOD OF OPERATING VALVE

What, then, is a Corliss engine, and why does George H. Corliss justly stand, in the popular estimation, by the side of James Watt as a factor in bringing the engine to its present state of efficiency?

George H. Corliss was born on June 2, 1817, at Easton, N. Y. He acquired an academical education at Castleton, Vt., and in 1844, at the age of 27, he went to Providence and associated himself with John Barlow and Edwin J. Nightingale, under the name of Corliss, Nightingale & Co., for the manufacture of steam engines. His only previous manifestation of inventive ability had been the production of a machine for sewing leather, his connection with which is doubtless responsible for the oft-repeated assertion that he was brought up a harness-maker. His senior position in the new firm was probably due more to the means and influence which he had already acquired than to any promise of exceptional engineering talent.

But Corliss was a man who went to the bottom of things. He had not been in the engine business long before he saw the weaknesses of the machine as then built, and in 1848 he applied for the first patent for his improvements. This patent was issued on March 10, 1849, and the first thing it goes into is the bracing of the frames of beam engines.

"The third part of my invention," he says in his application, "relates to the method of regulating the cutoff of the steam in the main slide valves, and consists in effecting this by means of the governor, which operates cams, so that when the velocity of the engine is too great, these cams shall be moved by the centrifugal action of the regulator, that a cam on the valve rods may sooner come in contact with them to liberate the valves and admit of their being closed by the force of springs or weights, and thus cut off the steam in proportion to the velocity of the engine."

His claim relating to this feature is as follows:

"I claim the method of regulating the motion of steam engines by means of the centrifugal regulator, by combining the said regulator with the catches that *liberate* the steam valves by means of movable cams or stops, substantially as described."

How could Corliss get this claim allowed with Allen's patent and the existing descriptions of other automatic cutoffs before the examiners? Because Corliss' was a *liberating* gear. It dropped the valve when the governor said so, and let it get closed as quickly as weights or springs could close it. In Allen's and the other cases, cams opened the valves,

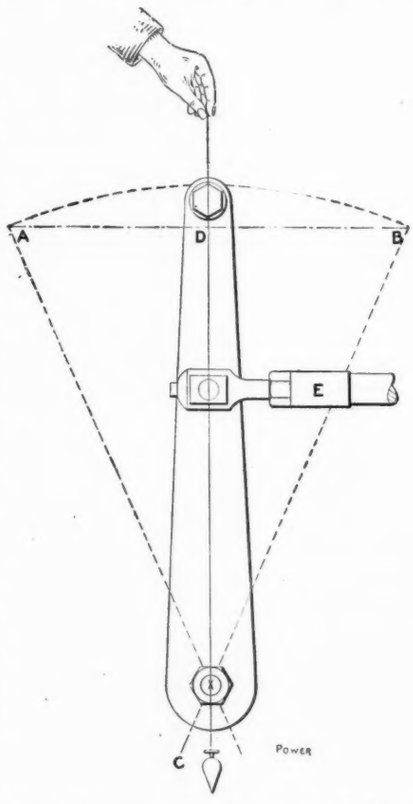


FIG. 3. EQUALIZING TRAVEL OF ROCKER ARM

and without releasing them placed them back in the closed position. In an application for a reissue of one of his patents, in 1859, he said:

"I wish it to be understood that by the term 'liberating valve gear,' as I have used it in this specification, I do not include those previous arrangements for working valves, which consist of cams or various forms to open the valves and then, at certain periods of their rotation, suffer the valves to be closed by the force of weights or springs, but control and graduate the closing movement. Such arrangements of valve gear lack the capacity for varying the periods of closing the valves, combined with the promptness of closing at all speeds of the engine, which characterizes my improved valve gear."

We have, then, as a distinctive feature of the Corliss engine the liberating, or detaching, valve gear under the control of the governor. Sickels had the detaching gear, but he had not specified it as a means of speed control nor combined it with the governor. Allen had the automatic cutoff, but not the detaching mechanism, and yet their combined inventions did not make a Corliss engine.

In the valve gear, the method and mechanism for operating the valves, considered apart from the governing feature and the particular form of the valve, lies the feature of the Corliss engine the originality and ingenuity of which are unchallenged. This invention is described in his first patent application as follows:

"In steam engines operated with slide valves, particularly the large condensing engines used in England, the valves are connected together and move together in pairs, one at each end of the cylinder, and therefore move together over the same extent of surface; and as the power required to move them is due to the friction produced by the pressure of the steam on their surface, and their range of motion under this pressure, it follows that the valves, while closed, require the most power, for much of this friction is relieved the moment the valves are partly opened.

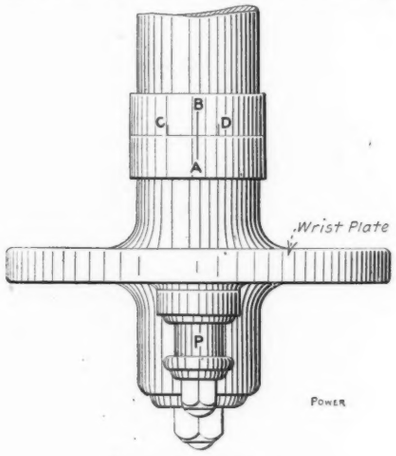


FIG. 4. WRISTPLATE

"One of the valves must always be closed while the other is being opened or closed; hence the closed valve is moved at an entire sacrifice of power.

"To save this several devices have been resorted to, such as cams, the irregular working of which makes too much noise and renders the whole liable to derangement; but by my invention I am enabled to reduce the motion of the closed valve relatively to that of the other valve, and thus greatly to reduce the amount of power hitherto required for this purpose. This, the second part of my invention, therefore consists in communicating motion to the two valves from one rock shaft,

by connecting each valve with a separate arm or crankwrist of the rocker, the two arms making such an angle with each other dependent upon the position of the valves and the rocker, so that the point of connection of the closed valves shall vibrate near the dead point and therefore give but a small amount of motion to that valve, while the other, which is being opened and closed, is moving along that part of its circuit which shall give the greatest longitudinal motion, and therefore giving to that valve the greatest amount of motion."

The meaning of this will be apparent from Fig. 2, where it will be seen that the crank in moving from its present to its dotted position would give a considerable movement to the valve to which it is connected, while the other crank would give little movement to its valve.

It is a singular fact, in view of the widespread impression that Corliss' principal contribution to the engine was the automatic cutoff, that this really distinctive feature of his engine applies with most of its force to the exhaust valves, for the idle steam valve is detached from the operating mechanism, and is not in a position to profit by its advantages. The natural development of the idea, however, was to operate all four valves from a single oscillating member, and the valve gear took the form of the four operating levers attached to the familiar pumpkin-seed-shaped wrist plate, with centers so located that the valves received their quickest movement in opening and closing, and remained practically still when the necessary movement had been accomplished.

On all but the smaller engines the motion is transmitted from the eccentric through a rocker arm, and as this motion will be distorted if this arm is allowed to vibrate to unequal distances to either side of its center of suspension, the first operation in setting an engine in which such an arm is used is to equalize its travel. This is most easily done for a horizontal engine by dropping a plumb line through the center of suspension, as in Fig. 3, turning the engine over slowly or rotating the eccentric and adjusting the stub-end E, or whatever other adjustment is provided, until the distances AD and BD to which the arm travels to either side of the center are the same.

On the stud which carries the wrist plate will be found three marks like BCD in Fig. 4, and upon the wrist plate a single mark like that at A. Hook in the rod which connects the wrist plate with the rocker arm, turn the engine slowly and adjust the stub-end upon the hook rod until the mark A goes out to both C and D, and does not travel beyond either. This does the same thing for the wrist plate which has previously been done for the rocker arm.

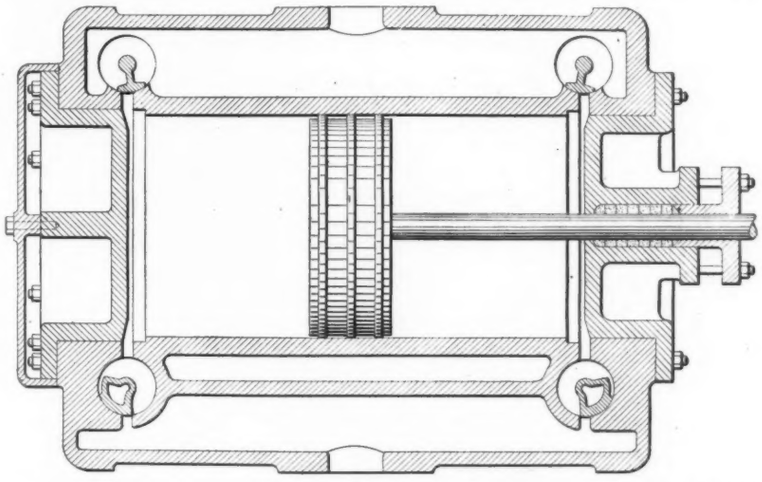


FIG. 5. DIAGRAMMATIC REPRESENTATION OF CYLINDER, CRANK AND ECCENTRIC

A diagrammatic representation of the cylinder and the crank and eccentric is given in Fig. 5. The connecting mechanism can be imagined. The eccentric is set, as you know, something more than 90 degrees ahead of the crank. Disregarding the slight distortion due to the angularity of the eccentric rod, the wrist plate will be in its central position when the eccentric is on the quarter, or in a position at right angles to the axis of the engine, at which time the crank will be approaching the center but some distance away. When the shaft has turned halfway around and the eccentric is again perpendicular to the engine axis, the wrist plate will again be in its central position, and the crank will be in the same position with regard to the other center, so that the position of the valves when the wrist plate is on the center must be the same for both ends.

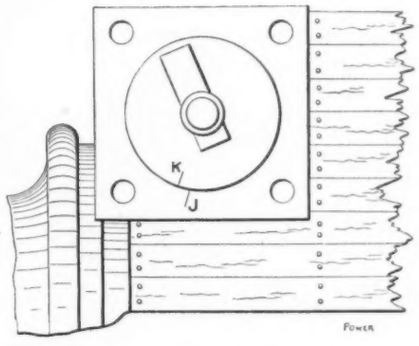
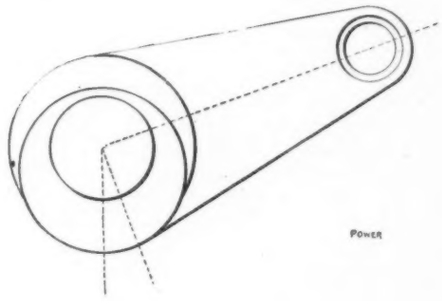


FIG. 6. VALVE WITH BONNET REMOVED

The piston has not yet reached the center; it is too early to open the steam valves, so that for this position of the wrist plate they should have some lap. With the exhaust valves we encounter conflicting conditions. The stroke is uncompleted but nearing its end. In one end of the cylinder the expanding steam must be released if we want a free exhaust; in the other the exhaust valve must be closing if we want compression. We have just seen that in the central position of the wrist plate the valves must be set alike on both ends. Now if we set this exhaust valve closed to get more compression, we must set the other one with an equal amount of lap, and may hamper the release upon that end, and if we do not set it the same it will be at the same disadvantage with regard to compression that we are trying to correct in this valve. Further, the very lap which we are putting onto this valve to get compression will be in the way when we are trying to open this valve early for release.



The best that can be done with an engine in which the motion for all four valves is taken form a single wrist plate is to compromise between the release and the compression. Set it for as little compression as you can get along with, which will be doing the best you can for the release. With a noncondensing engine a very good distribution can be gotten in this way, as neither the release nor the closure for compression has to be so early as in the condensing engine, where there is a considerable drop from the terminal to the vacuum pressure and an early release is imperative if the toe of the diagram is to be kept down and the full vacuum area realized; and where it is necessary to close the exhaust valve early in order to compress the thin vapor of the vacuum to a pressure which will arrest without shock the momentum of the moving parts. For the ordinary condition the exhaust valves of such an en-

gine should be open from a thirty-second to three-sixteenths, for engines up to 42 inches in diameter, when the wrist plate is in its central position. Tables of lap for the steam valves and of opening for the exhaust valves are published in various books, or can usually be obtained from the builder for the particular engine in hand.

If you take off the back bonnets you will find something like Fig. 6. The little marks at *J* and *K* show the positions of the working edges of the port and valve, as shown in Fig. 7. With the steam valves hooked on put the mark on the wrist plate in line with the central mark on the stud, and if your previous work has been accurate, the wrist plate will be in its central position. Now lengthen or shorten the connections between the steam valves and the wrist plate by means of the right and left connections until the distance between the marks *J* and *K* is equal to the desired lap. *K* should stand with reference to *J* so that it will move toward it on the opening movement of the valve. Some builders make their valves open toward and others away from the cylinder. Adjust the exhaust valves with the desired opening in the same way. For every material change in the length of the steam-valve connections there must be a corresponding change in the length of the dashpot rods. If they are left too short the valves will not hook up, and if they are too long the closing shoulder on the moving member of the steam-valve operating mechanism will bring up against the block before the wrist plate has reached the end of its travel, and something will have to bend or break. Make the length such that when the dashpot piston is thoroughly bottomed the valve will hook on easily and still so that there is plenty of clearance for the closing block, dividing the leeway substantially equally between the two. Now hook on the eccentric, put the engine on either center and turn the eccentric ahead of the crank in the direction in which the engine is to run until the steam valve has the desired amount of lead. If the work has been accurate the lead will be the same on the other end.

The position of the eccentric ahead of a right angle with the crank is called the "angular advance," and it is desirable to keep this as small as possible, first because the motion of the eccentric available for opening the valves becomes sluggish as it gets away from the quarter, and it is desirable to have the valve opened sharply, and secondly because by increasing the angular advance you decrease the range through which the engine can cut off. The cutoff is effected, as you know, by the contact of the releasing mechanism with the little cam, the position of which is controlled by the governor. The releasing mechanism is pushed toward this cam by the wrist plate as it moves away from its central position. If the contact does not occur on this outward movement it cannot occur at all during that stroke for when the wrist plate starts back it is drawing the mechanism away from the cam.

It is evident that this outward movement of the wrist plate in either direction occurs only during one-quarter of the revolution of the eccentric, and if we use up a large proportion of this quadrant in angular advance we shall have so much less of a range through which the governing mechanism is effective, and the earlier in the stroke will the engine commence to hang on.

All of the above applies to the admission valves. For the exhaust valves, on the contrary, considerable angular advance would often settle an awkward conflict between the release and the compression. I have pointed out before that if you add lap here to make the valve close earlier and get more compression, the lap will be in the way when you want to open the valve early and get a free release. But moving the eccentric ahead makes everything earlier and would quicken both release and closure for compression. So here is another compromise which we must make, this time between admission and exhaust. The position of the eccentric is determined, in the directions which I have just given you, by the lap which is given to the steam valves, because you set the eccentric ahead until with that lap the engine has the desired amount of lead, and this is the controlling factor in making up the tables to which I have referred.

In 1884, W. E. Crane, at that time in charge of the steam plant of Benedict & Burnham, at Waterbury, Conn., hit upon the idea of using a separate eccentric for the exhaust valves. This results in but little complication, and gives one a large latitude in adjustment, wiping out both of the compromises to which I have referred, for it divorces the steam valves from the exhaust valves altogether, and as adding lap makes the compression early and the release late while setting the eccentric ahead makes both earlier, you can get all the compression you want by lap, and set the eccentric so as to still open the valve in time for the release. In writing of this experience Mr. Crane says:

"I placed the two wrist plates in a vertical position and connected the steam valves so that each had $\frac{1}{16}$-inch lead. The exhaust valves were given $\frac{1}{8}$-inch lead. The eccentrics were placed at right angles to the crank and connected up. The steam eccentric was fastened to the shaft in that position, while the exhaust eccentric was advanced about 30 degrees.

"The engine had a cylinder 28 inches in diameter, and an attached condenser with a vacuum of 28 inches. Setting the steam valves in the above manner enabled me to get a range of cutting off from 0 to $\frac{3}{4}$-stroke, which made regulation very close, and very slight speed change in irregular work. The exhaust valves opened sufficiently early to get full vacuum at the commencement of the stroke and also had sufficient compression.

"With a noncondensing engine it is not necessary to advance the exhaust eccentric more than about 20 degrees. On a compound engine I have given the low-pressure steam valves $\frac{1}{2}$-inch lead and not found it too much. With valve stems, as usually splined, it will not be possible to set them as indicated above. If you have an engine just building, the valve stems can be splined that way in the first place.

"With stems already in use it will be necessary to take the stems out, turn them over and make new keyways. With the old style, where the blade was laid in a slot in the valve, it will require an offset key, or some other method of arranging the key, to get the above results."

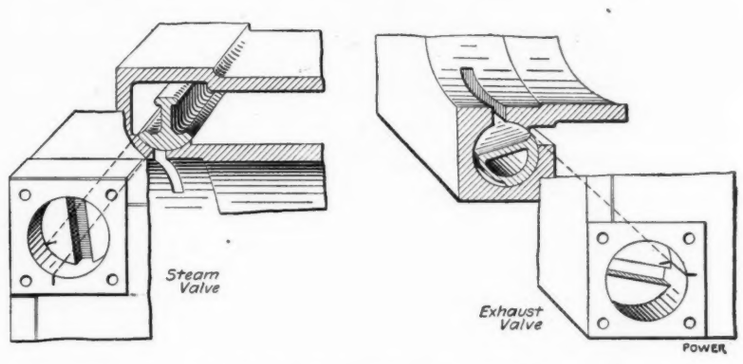


FIG. 7. STEAM AND EXHAUST VALVES

It now remains to adjust the governing mechanism. The three esentials are that the valves shall not be able to hang on long enough to give the engine steam when the governor is in its highest position in order that the governor may be able to prevent the engine from running away when there is no load, that the valves may not hook on at all when the governor is in its lowest position in order that the engine may not get steam

and run away in case the governor belt breaks or the governor becomes otherwise deranged, and that the cutoffs be equalized between the two ends on the average load. It is not possible, with the usual arrangement to so adjust them that they will be equal for all loads, for the movement of the piston, due to the angularity of the connecting rod, is different in the two ends of the cylinder, while the motion of the wrist plate, due to the much smaller angularity of the eccentric rod, is much more nearly equal on either side of its central position. The governor in descending a certain distance moves the knock-off blocks back an equal distance on both ends, and the piston has to move further in one end of the cylinder to turn the crank and the eccentric far enough to make the wrist plate push the releasing mechanism up against the cam in one end than in the other. This difference varies for different parts of the stroke, so that if it is corrected for one point of cutoff the correction will not be right for another.

The different angularity of the governor rods is also a feature. It would seem as though some simple mechanism might be interposed to make the movement of the cams vary in the same way as that of the piston, and I recommend it to you as a field for the exercise of your ingenuity. In the meantime the best we can do is, as I have said, to equalize the cutoffs for the average load. Perhaps the best way to go about it is to block the governor in its highest position, and adjust the length of the governor rods so that when the wrist plate is worked with the bar the hook will let go of the valve before the steam port gets open, which will be when the wrist plate has passed the central position a very little, for you will remember that the tables call for the valve to be lapped some when the plate is at the center of its travel.

Now if you cut off usually, as you should, at about quarter stroke, place the engine in that position, block the governor up to its normal running position, hook the wrist plate in and adjust the governor rod of the end which should just be cutting off so that the cam will be in contact with the releasing mechanism. Turn the engine over until it has made one-quarter of its stroke upon the other end, and repeat the operation. Now block the governor in its highest position and see that you have not allowed the engine to get steam under that condition. If you have, you must take care of that point. Perhaps you can do so by raising the collar which confines the upward movement of the balls. If not you must choose a higher position for the normal. If everything is all right, adjust the safety cams so that they will prevent the valve from hooking on at all when the governor is in its lowest position.

If the engine is a large one and difficult to turn over, the equalization of the cutoff can be done while running, all the better if you have an indicator. Here you simply shorten one rod and lengthen the other until the diagrams are alike. If you get either of them too short to cut off before the engine gets steam in the highest position of the governor, you must lengthen both, and look out for those safety cams.

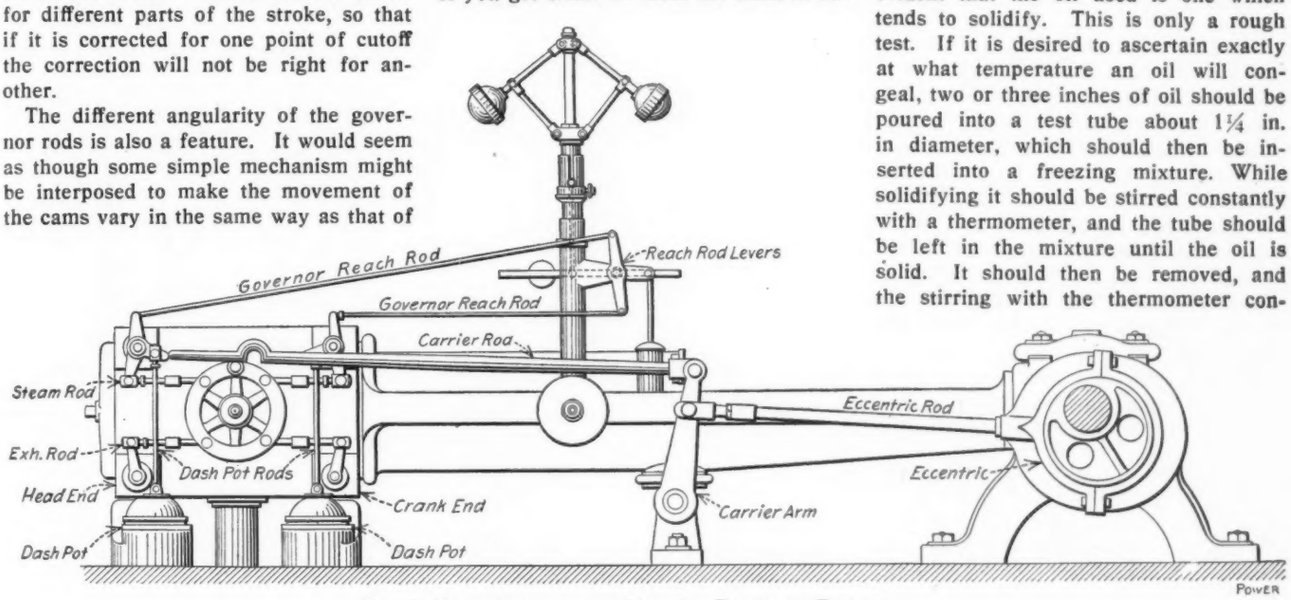


FIG. 8. NOMENCLATURE OF VARIOUS PARTS OF ENGINE

Testing Lubricating Oils

BY FRANCIS H. DAVIES

Scientific testing of lubricating oils is outside the province of the average engineer, needing as it does elaborate apparatus and special chemical training. Still, it is very desirable that the man responsible for the running of a plant should be able to make at least a few elementary tests, as oil has directly and indirectly a material bearing upon operating costs.

A simple method of ascertaining whether an oil contains acid or not is to immerse a polished copper plate in it for a few minutes. If no acid is present there will be no change in the appearance of the plate, but a trace of acid will dim the surface.

To determine whether a mineral oil is pure and well refined, a small quantity of strong sulphuric acid should be added to a sample. This will have no effect on the color of the oil if it is pure, but if it contains fatty material of any sort, discoloration will result. The addition of sulphuric acid has the effect of raising the temperature of an oil. An increase of temperature of about 20 deg. C. is the maximum that should occur with a good oil.

The solidification temperature of a lubricating oil is an important matter, and an approximate idea of the nature of any particular sample may be obtained by smearing it over the surfaces of two polished iron plates and laying them together. They should then be left for some days. If they do not move as freely over one another as at first it is evident that the oil used is one which tends to solidify. This is only a rough test. If it is desired to ascertain exactly at what temperature an oil will congeal, two or three inches of oil should be poured into a test tube about 1¼ in. in diameter, which should then be inserted into a freezing mixture. While solidifying it should be stirred constantly with a thermometer, and the tube should be left in the mixture until the oil is solid. It should then be removed, and the stirring with the thermometer continued until the oil becomes liquid and clear. The temperature of the oil when the last portion becomes fluid, is the temperature at which solidification begins to take place. For accuracy, this test should be repeated several times and an average result obtained.

When testing mixed oils having both mineral and fatty constituents, an approximate idea of the proportions of the two for purposes of comparison may be obtained by mixing a small quantity of the oil with a strong solution of caustic potash. If the mixture is well shaken, an emulsion will be formed varying in proportion to the quantity of fatty matter present. This test is useful for making a rough comparison between several oils, but it does not give any indication of the relative proportions of the two ingredients in any one of the oils. With a pure mineral oil there will be at most a slight cloudiness, but saponification will be marked if either animal or vegetable fats are present.

Flue Gas Analysis for Beginners—II

By J. E. Terman

Directions for operating Orsat apparatus, adjusting level of reagents, measuring a sample and testing for carbon dioxide, oxygen and carbon monoxide.

Manipulation of the Orsat Apparatus

To become familiar with the manipulation of this apparatus, instead of a gas sample from the stack, air may be analyzed, or, to have CO_2 present in measurable quantity, a sample of the operator's breath may be used. The first operation to understand is the adjustment of the reagents in the pipettes. A line on the neck of each pipette below the glass stopcock, as at *A*, Fig. 1, indicates the proper level of the reagent after passing the gas sample into and out of the pipette. Approximating this level is sufficient, for the bore of the tube is so small that a trifle higher or lower level is practically without effect on the measurement of a sample.

For adjusting the reagents to these lines, the leveling bottle *L*, Fig. 2, is filled with water and connected to the bottom of the burette by about 30 in. of rubber tubing, then, with cocks *K* and *G*, Fig. 2, open, raising the bottle above the apparatus will fill the burette with water, when the cock *G* should be closed. Now, after opening the cock connecting the first pipette to the burette *N*, Fig. 2, the reagent may be caused to rise in the pipette to the guide line by lowering the bottle sufficiently; then the cock should be closed. Many place the leveling bottle at some fixed low point, and depend on shutting off the cocks at the

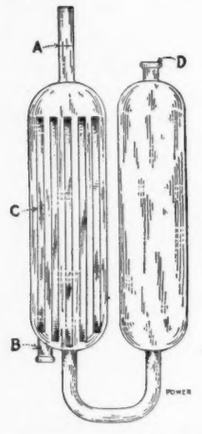


Fig. 1. Pipette with Glass Tubes in Place

right instant to prevent the reagents from running up too far in the tube, but the writer prefers the other procedure.

With the reagents adjusted in all the pipettes, the rubber bags protecting the outlets of the rear legs of the pipettes, connecting *D*, Fig. 1, should be removed for an instant to restore the atmospheric pressure within this portion of this pipette where a partial vacuum was produced during the adjusting of the reagents. For the last two pipettes, the rubber bags will have to be removed several times, as the reagents in them absorb oxygen from the air. This persistent reducing of the pressure will interfere with subsequent manipulation of the gas sample unless the pressure is repeatedly equalized.

Measuring a Sample of Gas

The next step is to learn to measure a sample correctly. A sample of breath to be analyzed may be collected in one of the sample bottles, Fig. 3, by opening the pinch-cock *Q* and holding the end of the tubing at *P* in the mouth, then opening the pinch-cock *P* and blowing into the bottle to replace the water flowing out of the bottom connection *Q*.

After filling the burette with air, both cocks *P* and *Q* are closed and the bottle placed near the left end of the apparatus. The end of the tubing which was held in the mouth should be connected with the end of the main connecting pipe at *H*, Fig. 2, and a second bottle, similar to that in Fig. 4, containing water, connected to the bottom of the sample bottle at *Q*, Fig. 3, as illustrated in Fig. 4. This last bottle should be elevated slightly above the sample bottle to put the sample under a light pressure. This is always advisable to prevent infiltration of air if there is any leak.

For measuring a sample, the method originated by Prof. Gill is doubtless the most simple and effective. He compares it to measuring a bushel of grain by heaping up the measure and then striking off the top with a straight-edge. More gas than required is drawn into the measuring burette and compressed until it occupies just the volume desired; then opening the cock *G*, Fig. 4, permits the excess gas to escape.

Before drawing the sample of gas into the burette, sufficient water to fill the bottle and its connecting tube up to the bottom of the burette, should be placed in the leveling bottle *L*. During the filling of the bottle, the cock *G* should be open to the air; then, with *G* and *K* still open, the bottle should be raised until the burette and the main connecting pipe to the pipettes are filled with water, after which *G* should be closed. This cock *G*, Fig. 4, is a three-way cock, and can close the end of the main connecting pipe, or open it to the atmosphere, or connect it with the end *H*, Fig. 2. Opening cocks *K* and *H*, Fig. 4, and lowering the leveling bottle, will transfer the sample from the bottle to the burette. When the sample reaches a point 1 or 2 c.c. below the zero mark in the burette, the pinch-cock *K*, Fig. 4, and the cock *G*, should be closed.

Examining the burette will show drops of water trickling down the sides. As these occupy space used to measure the gas sample, they should be eliminated before actual measuring begins, although this is not as important as to have the amount left at each measurement the same. One per cent. of the space could be occupied by moisture at every meas-

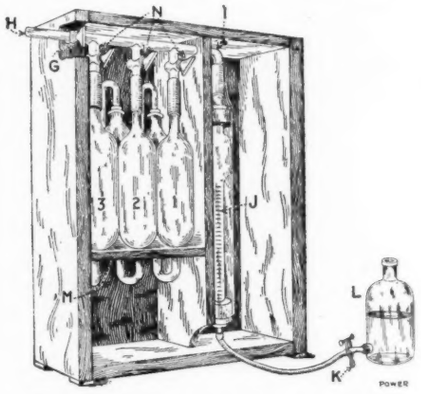


Fig. 2. Orsat Apparatus Assembled

urement of gas without appreciably affecting the result of the volumetric analysis, but if, at one measurement, the sides of the burette were practically dry, and at the next, 1 per cent. of water was clinging to the sides, serious errors would result.

To obtain uniform conditions, a fixed time must elapse after the gas has been run into the burette so that the water can drain down the sides before measuring the volume of the gas. One minute is enough. A sample should be measured at the same pressure all through an analysis. Any pressure would do, but atmospheric pressure is most convenient as it can be obtained by simply bringing the water in the bottle and the burette to the same level, having the cock *K*, Fig. 4, open, for the mouth of the leveling bottle is open to the atmosphere. Keeping the temperature of the gas sample constant during the analysis is also important and is the reason the burette is jacketed with water. Advisable also is keeping the apparatus unexposed to drafts.

After one minute has elapsed for draining the water from the sides of the

burette, the leveling bottle is raised, with cock *K* open, until the sample in the burette is compressed to exactly 100 c.c. Now, closing the pinch-cock *K* and opening cock *G* to the air, the excess of gas escapes, after which cock *G* should be closed to retain the sample intact. Next cock *K* should be opened and the water in the bottle brought level with that in the burette, as a test of the measurement, which should show 100 c.c. at atmospheric pressure. Sometimes a little moisture will obstruct the opening through *G*, thus retaining a small excess of the sample, in which case a little larger excess of gas should be drawn into the burette from the sample bottle and the operations described repeated.

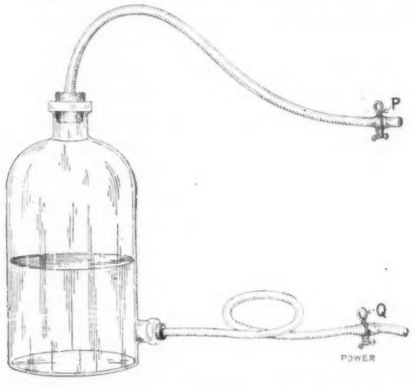


FIG. 3. BOTTLE FOR COLLECTING GAS SAMPLE

ANALYSIS OF SAMPLE

As explained in the first article, the pipette next to the burette, No. 1, Fig. 2, contains the caustic potash solution, the middle one, No. 2, potassium pyrogallate and No. 3, acid cuprous chloride. Most writers on flue-gas analysis fail to impress on the beginner that speed in using the Orsat apparatus can be attained only by keeping the gas agitated, while it is in the pipettes, and in contact with the surfaces of the glass tubes wetted by the reagents. The only ways to produce this agitation are to shift the gas sample back and forth between the burette and the pipette, or agitate the reagent by pressing on the rubber bag connected to the outlet *D*, Fig. 1, of the rear leg.

If the entire sample of gas is shifted between the burette and the pipette containing the caustic potash solution, about four or five times, the absorption of CO_2 is usually complete, but more passes may be needed, as several things tend to vary the rate of absorption, such as the condition of the reagents, the temperature and, possibly, the composition of the gas. If measurements of the volume of the gas after consecutive passes, tally to within 0.01 per cent. for CO_2 or O, the absorption may be considered complete, but for CO, two consecutive readings should tally as nearly as can be determined by the eye.

To hasten an analysis these comparative readings may be made immediately after the sample has been run into the burette instead of waiting a minute for drainage. If the two consecutive readings compare favorably, the final reading may be taken after a minute has elapsed from the time the gas is returned to the burette, including the time occupied by the comparative reading.

While shifting the gas back and forth between the pipette and the burette, it is most convenient to leave the cock connecting the pipette open, and control the flow of the gas entirely by the position of the leveling bottle, until time to measure the volume. Then the reagent must be brought back to about the level of the mark on the pipette stem, the cock closed and the water levels in the bottle and the burette made the same.

With a breath sample, the CO_2 content will probably be from 2 to 4 per cent. of the total volume and may be noted on the paper pasted on the inside of the frame. To determine the O, the apparatus is manipulated as before, but more time is required for absorption, generally about twice as much as for CO_2, or say, eight or ten passes, and complete absorption is again judged by comparing consecutive volume readings until they agree within reasonable limits. The O absorbed is also noted on the paper slip, and from the breath will be about 17 to 18 per cent., if the CO_2 is 3 per cent., for the total oxygen in the air is about 21 per cent. by volume.

If the gas sample had been drawn from a furnace, the determination of CO would be the next step, but, as none of this is present in the breath, it would be useless to test for it. The process of testing, however, is identical with the other two, except that the reagent is far less active than those used before, and consequently more time and more care are necessary in making the comparative readings between the passes of the sample into the burette. In regular flue-gas analysis, usually little or no CO is present, and small inaccuracies in the determination are relatively more important than for CO_2 or O. The small quantity of CO, usually found, and the uncertain action of the reagent, make this part of the test very unsatisfactory.

The remainder of the gas is assumed to be nitrogen. In obtaining each successive percentage the amounts previously absorbed are deducted from that shown by the measurement in the burette. Starting with 100 c.c. of a sample and having 10 c.c. absorbed in the first pipette, indicates 10 per cent. of CO_2; if after analyzing for oxygen 19 c.c. has been absorbed 19 — 10 = 9 c.c., or 9 per cent. of O was present, and if finally the total volume absorbed is 19.6, then 19.6 — 19 = 0.6 per cent. of CO was present.

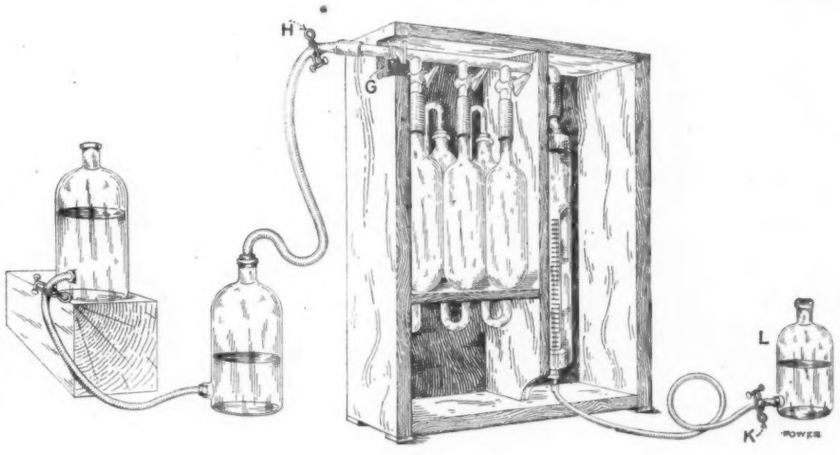


FIG. 4. GAS TRANSFERRED FROM SAMPLE BOTTLE TO BURETTE

An Oriental Lighting Plant

The installation of a 500-lamp electric-lighting plant in the Sultan's palace in Arabia has just been completed. This is the first instance of the operation of any sort of electric machinery in that country.

Permission has been granted to operate a commercial lighting and power plant employing two 30-kw. dynamos for supplying current for several thousand lamps. One set of machines will be run at night and the other in the day, principally for the purpose of driving fans which, on account of the great heat and the difficulty of securing energetic punkah pullers, are much needed. Power will be furnished by oil engines and direct current will be used.

Putting steam boilers in charge of incompetent men is as foolhardy as sitting with a lighted cigar on an open can of gunpowder. The chances are good for an explosion in either case. Two instances of boiler explosion have recently been reported and in each the boiler attendant was killed.

Electrical Department

Conducted to be of service to the men in charge of electrical equipment in the power house

Inspecting and Testing Electrical Apparatus IV

By A. L. Cook

Transformers

There are three general classes of transformers used for power supply:

1. The air-blast type in which all the insulation is of a solid nature and cooling is accomplished by forcing a current of air through the windings and laminations. This type is made for voltages up to 33,000 and in capacities up to 3000 kv.-a.

2. The oil-insulated self-cooling type, in which part of the insulation is of solid character, the remainder consisting of the insulating oil in which the windings and core are immersed. This type is cooled by radiation from the containing tank, the oil serving to conduct the heat from the windings. They are made for any commercial voltage and in capacities up to about 3000 kv.-a.

3. The oil-insulated, water-cooled type is similar to the preceding type with the addition of coils of pipe immersed in the oil through which cooling water is circulated. These transformers are made for any voltage and in any capacity up to 10,000 kv.-a.

Oil-insulated transformers are frequently shipped completely assembled, with the oil in the tank. In this case the transformer has only to be put in place and connected to the circuit. Air-blast and oil-insulated transformers shipped out of the oil generally require drying out after installation; the necessity depending upon the voltage and the condition of the windings as regards moisture. Sometimes the windings of oil-insulated transformers are shipped in sealed tin cases; hence do not require drying unless the case has become damaged.

Transformers of small capacity can be dried out by passing current through the windings. The transformer should be left in the packing case, with openings at the top and bottom to allow air circulation and the low-voltage windings short-circuited. Alternating current at normal frequency should be passed through the high-voltage windings and should be so regulated that the temperature of the windings in the hottest parts will not exceed 160 deg. F. To obtain the proper temperature will generally require about one-fifth full load current, and a voltage about 2 per cent. of normal; in no case should 150 per cent. of full load current be exceeded.

For large transformers it is also desirable to apply external heat, to assist in the drying-out process. This can be furnished by incandescent lamps or iron-wire resistance coils placed at the bottom of the case. If the latter are used, the windings near the resistances should be shielded from the direct heat and the resistances must be installed so as to avoid danger of setting fire to the packing case or windings. Where it is impracticable to use current for drying out, heated air may be passed into the bottom of the case by a flue. Care should be taken, however, that the gases of combustion are not carried into the transformer. Drying out a transformer may take a week or more of continuous operation, depending upon its size. If current is used, a switch should be provided so that it can be cut off readily if the temperature rises too high. Where impossible to get exactly the right voltage to hold the temperature steady the current can be cut off at intervals.

When drying out transformers, they should always be inclosed to assist in retaining the heat and only a slow circulation of air allowed; sometimes it is convenient to place the windings in the tank for this purpose. Transformers for voltages of 40,000 and above, require special drying methods, one of the best of which employs a vacuum.

It is impossible to tell when a transformer is entirely dry, but measurement of the insulation resistance between the windings and the core by means of a suitable voltmeter is sufficient for practical purposes. To get satisfactory results, use either a 600- or a 750-volt standard voltmeter with a 500-volt circuit, or a special high-resistance voltmeter may be used with 125 volts. The ordinary voltmeter used on 125- or 250-volt circuits would not, in general, be satisfactory, as it could not measure high enough insulation resistance. When using a voltmeter on a grounded circuit, the meter must be connected in the side which is not grounded, and the lead between the voltmeter and the apparatus tested should have good insulation so as not to affect the readings. It is also well to test the switches connected to the windings when drying out, to see that they have a high insulation resistance. When testing the leads or switches alone, there should be no reading of the meter. Tests of the insulation resistance should be made at intervals of 2 or 3 hr. and the drying process continued until the resistance remains constant for several readings, with the temperature of the coils remaining the same; the transformer can then be filled with oil if this is used.

It is important that the oil be free from moisture. If water is found in the bottom of the barrel, or there is reason to suspect its presence, the oil should be tested. Various tests are recommended for detecting moisture in oil; none of these, however, except the high-voltage test, gives conclusive results, although the use of dry copper sulphate is fairly satisfactory. To prepare the copper sulphate, ordinary blue vitriol may be heated to a moderate temperature until all the water is driven off and a fine white powder remains, a small quantity of which can then be shaken up in a bottle containing a sample of the oil. If the powder takes on a bluish tinge it is an indication of moisture. The trouble with this test, as with others suggested, is that considerable experience on the part of the tester is required to detect the presence of small quantities of moisture. The only reliable method is to determine the voltage required to break down a definite gap between terminals immersed in a sample of the oil. If the approximate methods of test indicate moisture or there is reason to believe that such exists, the voltage test should be made, particularly on oil used in high-voltage transformers.

If moisture is found, it must be removed before the oil is used. When there is a large amount of water present, it will settle to the bottom of the barrel and can be drawn off from the bottom. This, however, does not leave the oil suitable for use, as it will still hold enough water in suspension to make its dielectric strength very low. To dry out the oil, it may be heated in an open tank, either by external heat or by resistance coils immersed in the oil, the temperature being maintained at about 220 deg. F. The oil should be well stirred and the temperature maintained for about 10 hr. or until the moisture has been removed. The objection to this method is that long continued heating of the oil changes its character, making it unsatisfactory for use in the transformers. If a vacuum outfit is used for drying the transformer windings, this can also be employed to advantage for drying the oil, since the temperature need then only be raised to about 160 deg. F. Oil can also be dried by passing it over unslacked

lime, for which purpose good clean lime should be used and the oil slowly circulated through it. Before being treated by the lime, the oil should be filtered through a piece of chamois skin, which will remove part of the water. It is well to filter the oil in this manner, irrespective of the final method of treatment.

When applying the voltage for the first time to a bank of transformers it is well to bring up the voltage gradually, using one of the generators for the purpose. The ammeter should be watched to detect any excessive current. This method not only tests the windings of the transformer but also tests the connections between transformers. When the voltage has been brought up to normal that on each phase of the high-tension side should be checked if there is a voltmeter in this part of the circuit. The apparatus is then ready for service.

Lightning Arresters

Lightning arresters having a number of metal gaps in series require only careful cleaning and inspection before applying the voltage. The electrolytic type, consisting of a number of aluminum trays nested together with the electrolyte forming a conducting path between adjacent trays, require a preliminary charge, however. To charge these for the first time, gradually build up the voltage on the arrester after it has been completely assembled, the voltage being applied through a 10-amp. fuse wire and gradually increased, either by regulating the generator voltage or by using the transformer with a water resistance. The voltage should be increased slowly, taking about 5 min. to reach normal and noting any noise in the arrester which would indicate that it was not in proper condition. A better method is to apply a low voltage to each pair of trays after they have been filled with the electrolyte but before being put into the tank. To do this properly, 220-volt alternating current is necessary, although 110 volts can be used to give a partial charge and 550 volts if two cells are charged at a time. A lamp bank giving about 2 amp. when the arrester is not in circuit, should be provided, and the charging leads should then be applied to two adjacent trays. At the first instant, the lamps will burn at full candlepower but in a few seconds they will dim considerably. If there is no change, the two trays are short-circuited, or the film has not formed. If the lamps are dim at first, this indicates either that the trays have not been properly filled, or that the tray is already charged. The indication with 110 volts will not be as definite as with 220 volts since the voltage is not sufficient to completely charge the trays. After the trays have been charged in this manner, they can be put in the tanks and the oil poured in; the arrester is then ready for service.

Feeders

Methods of testing feeders depend largely upon the normal voltage and the importance of the particular circuit. Underground feeders are generally more thoroughly tested than overhead feeders, since the condition of the latter can be partly determined by inspection. Low-voltage feeders, both overhead and underground, can be tested in the manner described for direct-current feeders. (See Article I of this series, Aug. 6 issue.) Medium- and high-voltage feeders should have a voltage test applied before putting in service. With overhead feeders, this is necessary to detect defective insulators; for underground cables it is necessary in order to test the splices as well as to make certain that the cable has not been damaged during installation.

Overhead lines for 11,000 volts and over, should, if possible, be tested at double voltage, applied for 15 min. between each wire and ground. This would require a high-voltage testing transformer, and suitable regulating and voltage measuring devices, and as such tests are justified only for long lines, they will not be considered here. If only the normal transmission voltage is available, the line may be tested by gradually raising the voltage on the line, using a generator for the purpose. Generally, this can be done by grounding one terminal of the testing circuit through a resistance and attaching the other terminal to all the conductors of the feeder. When the voltage is built up there will be practically full voltage applied between the conductors and the ground which gives them a test to ground about double the normal potential difference for a single-phase or two-phase line and about 70 per cent. more for a three-phase line. This test should be applied for about 15 min. The test also subjects the windings of the generator or the transformer to the same voltage. After making the test to ground, the line can be connected to a spare generator and the voltage gradually built up to normal; this will test for short-circuits between conductors.

High-voltage underground cables require careful testing during installation, and before putting in regular service. While the cable is being spliced it is customary to measure the insulation resistance at frequent intervals as a check on the splicers. These measurements have to be taken with special apparatus, however, as the voltmeter method is not sensitive enough. When the cable is completely spliced and ready, measurements of insulation resistance are first made and then a high-voltage test is applied. The testing voltage varies with the conditions, but generally double the normal voltage, applied for 5 min., is sufficient. Testing underground cables in this manner requires special apparatus and considerable care, and is of such a character that it can generally be made most satisfactorily by the manufacturers; hence no attempt will be made to describe the test here.

Relatively low-voltage cables, such as 2200 volts, or even short lengths of cable for higher voltages may not justify the expense of elaborate testing methods, but a test at normal voltage should be made, employing the method described for overhead feeders.

After the feeders have been tested, they can be connected up for regular service. If two or more connect to a set of busbars at each end, as in a power station and a substation, it is necessary to "phase out" before making permanent connections. To do this, connect one terminal of a test-lamp circuit to ground and the other to one lead of the feeder. The leads at the other end should then be connected to ground through a lamp, testing one lead at a time until the lamps burn. The lead can then be tagged at each end and the test repeated on the other leads. A diagram of connections for this test is given in Fig. 10.

Substations

After the feeders entering the substation have been phased out, the main wiring should be tested; the extent of these tests depending upon the size of the station and the voltage.

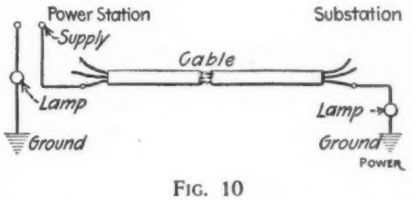


Fig. 10

The procedure to be followed for the inspection of the switching and metering equipment is the same as that described for power stations.

The adjustment and fitting of brushes on rotary converters should be made in the same manner as for direct-current generators, the brushes being given a slight forward lead. The transformers should be inspected and, if necessary, dried out as previously described. The alternating-current side of the converter should be disconnected from the transformers, either by raising the brushes from the slip rings, or by removing the leads, and the voltage gradually raised on the transformers to test the connections. When the applied voltage is normal, the voltage at the alternating-current brushes should be checked. For a three-phase converter, with three slip rings, the voltage between any two leads or sets of brushes should be identical, and about 61 per cent. of the direct-current voltage. For a two-phase converter with four slip rings, the voltage for each phase is about 71 per cent. of the direct-current voltage. Six-phase rotary

converters are frequently used on three-phase systems. The two common arrangements of the connections are "double delta" in which the secondary of the three transformers are divided into two parts with two independent deltas; and the "diametrical" where the secondary windings of the transformers are not connected together but are each run independently to a set of brushes. The alternating-current voltage is about 61 per cent. of the direct-current voltage for the double-delta connection, and about 71 per cent. for the diametrical.

Converters which are started from the alternating-current side can be phased out by closing the starting switch and noting the direction of rotation. Before doing this, the field switch provided on the machine should be opened. The correct direction of rotation is determined by the arrangement of the direct-current brushes, and if the machine starts in the wrong direction the rotation must be changed by reversing one phase of the alternating-current circuit either on the primary or secondary side of the transformers. Generally it is easier to reverse the primary circuit. In the case of a three-phase system, this should be accomplished by interchanging any two of the leads which connect to the delta of the transformers. It is not correct to interchange the connections of one of the transformers, but the change should be made in the circuit feeding the group. Therefore, it is good practice to make temporary connections between the high-tension circuit and the transformer delta so that this change can be made easily if necessary. A two-phase converter may be reversed by interchanging the leads connected to one of the transformers.

When converters are started from the direct-current side, or by means of induction motors, they must be phased out in a different manner. First, the starting devices must be tried out to see that the machine starts in the correct direction. If a spare generator is available, the converter can be easily phased out by gradually raising the voltage on the alternating-current side until the machine starts. Before doing this, the shunt-field circuit should be opened in at least two places by removing the connections between adjacent field coils, leaving about the same number of coils in each part of the circuit. This precaution is necessary to reduce the voltage in the field coils during the starting operation. Then the voltage can be gradually applied to the alternating-current side by slowly raising the generator voltage. The machine should start before half the normal voltage is reached; if it starts in the reverse direction, the connections must be changed as described.

After this test is completed, the field coils should be reconnected and the synchronizing connections checked.

Where it is not possible to raise the voltage gradually, the machine can be phased out with lamps. If there are switches in the leads between the slip rings and the transformers, these should be opened; otherwise, the leads must be removed from the brush-holder studs. Lamps should then be connected between each lead and the corresponding stud, or across the corresponding clips of the switch, using enough lamps in each group so that the sum of their voltages will about equal the voltage between phases. The proper connections of the lamps for three-phase and two-phase converters are shown in Figs. 11 and 12. The converter can now be started from the direct-current side, or by means of the starting motor. If a starting motor is used, a voltmeter should be placed across the direct-current terminals of the converter and its reading noted as the machine speeds up. The shunt-field rheostat should be partly cut out so that the voltage of the machine will build up in the same manner as a direct-current generator. If the machine fails to generate, or builds up in the wrong direction, the same procedure should be followed as for direct-current generators. If the machine builds up in the correct direction, the alternating current may be applied to the transformers. The lamps in the secondary circuits will vary at intervals from bright to dark, the rate of pulsation depending upon the deviation from normal speed. If the connections are correct, all the lamps will be dark at the same time. If the sets of lamps are dark at different times, either the primary or secondary connections should be reversed, as previously described, and the test repeated. If the change is correctly made, all lamps should be dark at the same instant, showing that the phases have the correct rotation.

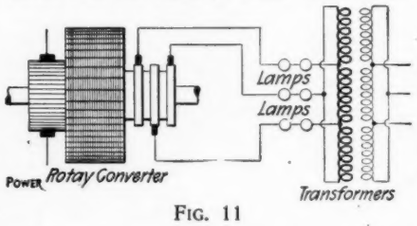


FIG. 11

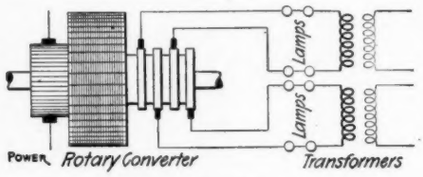


FIG. 12

The regular synchronizing connections should now be checked. To do this, all the alternating-current brushes should be raised clear of the slip rings, taking care that brushes on adjacent arms do not touch each other, or ground on the frame of the machine. If there is a switch in the secondary circuit, it should be closed and then the switch in the primary circuit of the transformers should be closed. The synchronizing lamp and the synchroscope, if there is one, should then indicate synchronism; if they do not, the synchronizing connections should be corrected. Having checked these connections, the transformer switch should be opened, the brushes replaced, and the machine synchronized in the regular manner. The converter is then ready to be connected to the direct-current busbars, the procedure to be followed being the same as for a direct-current generator.

If a synchronous motor is to be put in service it can be phased out in the same manner as a converter.

CORRESPONDENCE

Motors Will Not Carry the Load

Referring to Mr. Shrode's inquiry in the June 18 issue, it would appear that his 7½-hp. induction motor has been run with the belt too tight, thus causing excessive wear on the pulley bearing. If this has been taken up, and the belt runs with normal tension, I see no reason why the motor should slow down very much below normal speed unless too small for the load. It is assumed the applied voltage is that at which the motor is rated.

I would recommend that the rotor bars of the second motor of the soldered-disk type be tested for grounds. If found free from grounds, be sure to solder the disks securely to each rotor bar. It is essential that they be soldered well, since heavy currents flow in the bars during starting and during periods of heavy load.

BEN. DAWSON.

Cedar Rapids, Iowa.

Reversed Polarity

In the July 2 issue, Mr. Mitchel writes how he reversed the polarity of his direct-current generator by running two wires from the No. 1 machine to the field connections of No. 2. This is not necessary either to change the polarity or to charge the fields for lost residual magnetism.

To change polarity or to charge, all the brushes on the machine to be changed or charged should be raised and a piece of cardboard or heavy paper placed beneath to insulate them from the commutator. This can be done without loosening the brush-holder springs. If no paper is handy, the spring can be loosened, the brush raised and the clamp then tightened to hold the brush up. One should be sure that no brush touches the commutator. Finally opening the rheostat to running position and throwing in the machine or paralleling switch for a moment will reverse the polarity, or charge the field magnets as the case may be.

C. A. SCOTT.

Wales, Wis.

Gas Power Department

Worth-while gas-engine and producer information treated in a way that can be of practical use

Operating Costs at Willard Plant

By A. D. Williams

The plant at which these operating statistics were obtained is a part of the factory equipment supplying power for use in forming storage-battery plates and charging storage batteries. The plant operates upon a 24-hr. schedule, 7 days a week, as the process of forming storage-battery plates requires a continuous supply of direct current, which cannot be interrupted without interferring with the electro-chemical reactions. For this reason it was deemed inadvisable to depend upon central-station service. The original plant comprised the two 80-hp. units, one of which acted as a reserve; the 135-hp. unit was next added, then the 300-hp. machine. The later machines were selected so that sufficient reserve capacity would be available at all times to carry the full load on the plant.

The engineering force is divided into three watches of 8 hr. each; the chief taking the day run from 7 a.m. to 3 p.m. The other two watches, taken by the assistant engineers, are from 3 to 11 p.m. and from 11 p.m. to 7 a.m., except upon Saturday nights, when they change shifts with a dog watch of from 3 p.m. to 6 p.m. and a 13-hr. shift to 7 a.m. The load conditions are such that runs of from 7 to 20 days without a stop are frequent with occasional longer runs. In 1911 the 135-hp. unit was operated continuously for three months. The 300-hp. unit has eclipsed this, however, with a continuous run which started Dec. 26, 1911, and ended Apr. 6, 1912—102 days, the unit being started with only a 24-hr. shutdown intervening between it and a previous 19-day run. On Apr. 6, the machine was shut down to replace one of the exhaust valves and aside from this was in condition to have run much longer.

The operating cost statistic herein given cover the first four months of 1912. During this period the crank cases of all the engines were refilled with oil so that this item is higher, except in February, than the normal. The oil item also includes that used outside of the power plant for lubrication; this, however, is a small amount as comparatively little machinery is required in making storage batteries. The rental charge is based upon the floor space occupied and the insurance upon the plant valuation. The depreciation charge is upon a plant life for the machinery of 7 years. The labor charge includes, beside the engine-room force, part time of a laborer in handling the coal and ashes for the factory-heating plant. The water rate includes that used in heating as well as the engine cooling water. City water is used with a meter charge of 40c. per 1000 cu.ft. The engine cooling water passes through a home-made cooling tower, which has reduced the water bill between $150 and $200 per month, so that the tower pays

OPERATING DATA, WILLARD STORAGE BATTERY PLANT

	Jan.	Feb.	March	April
Rent of space occupied	$25.00	$25.00	$25.00	$25.00
Depreciation	303.86	303.86	303.86	303.86
Insurance	49.05	49.05	49.05	49.05
Water at $0.40 per 1000 cu.ft.	20.77	20.77	20.77	21.91
Gas at $0.30 per 1000 cu.ft.	511.80	501.60	552.60	615.20
Repairs	70.54	58.07	39.41	61.14
Oil	101.88	78.13	116.13	143.51
Miscellaneous	2.34	26.32	2.00	14.18
Labor	396.00	394.70	417.98	412.86
Totals	$1,481.24	$1,457.50	$1,526.80	$1,647.71
Deduct Credit items	9.05	387.38	364.59	541.02
Net total	$1,472.19	$1,070.12	$1,162.21	$1,106.69
Heating factory	314.01	328.43	169.89	78.00
Total, Power and Heating	$1,786.20	$1,398.55	$1,332.10	$1,184.69
Credit: Old oil barrels	$ 9.05	$ 3.55	$ 9.00	$ ....
Sale of energy		383.83	355.59	541.02
Total Credit	$ 9.05	$ 387.38	$ 364.59	$ 541.02
Heating: Coal and freight	$ 308.01	$ 319.43	$ 154.89	$ 72.00
Use of side track	6.00	9.00	15.00	6.00
Total	$ 314.01	$ 328.43	$ 169.89	$ 78.00
Kw. hours generated	122,428	119,856	135,690	135,572
Gross cost per kw.hr. generated	0.01210	0.01216	0.01125	0.01215
Net cost per kw.hr. generated	0.01202	0.01124	0.00857	0.00816
Cost of power and heating per kw.hr. generated	0.01459	0.01167	0.00982	0.00874
Load factor of generating plant	41.8	44.0	46.3	47.27
Total 1000 cu.ft. units of gas	1,706	1,672	1,842	2,054
Total cu.ft. gas per kw.hr. generated	13.935	13.950	13.575	15.153

The last items include all gas used in the power plant, for starting, when engines are running light and under partial loads. It is the average consumption of all the engines under the commercial loads they carry.

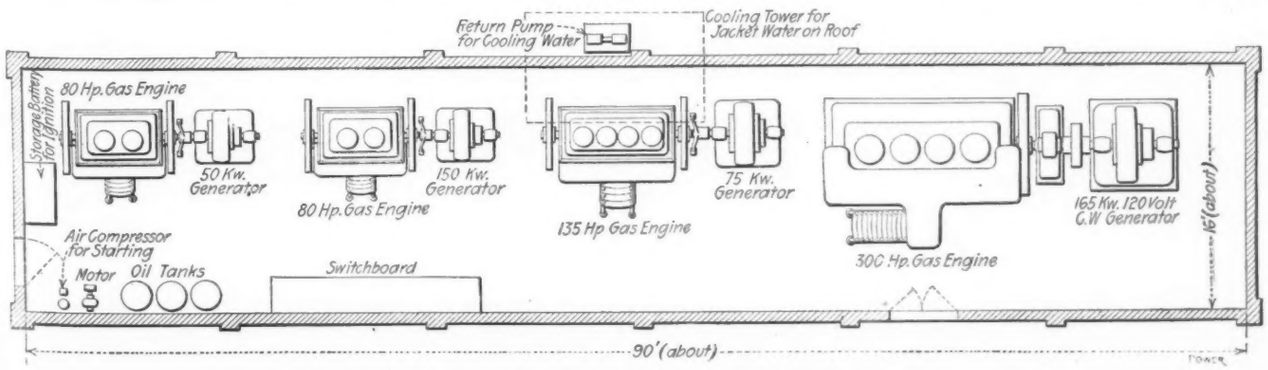


Fig. 1. Plan of Engine Room at Willard Plant

for itself from two to three times per year.

Only one item seems to be omitted, namely, the interest upon the money invested in the plant. The inclusion of this item, unless it has been lumped with the depreciation, would add about $0.00125 to the rate per kilowatt-hour.

For much of the foregoing data the author is indebted to J. F. Kalb, chief engineer of the plant, and to the Bruce-Macbeth Engine Co., who installed the engines.

FIG. 2. VIEW OF ENGINE ROOM; 300-HP. UNIT IN FOREGROUND

Preheating Gas Engine Charge

BY P. A. TANNER AND A. C. EDWARDS

Acting on the suggestion of the chief engineer of a well known gas-engine concern, the authors conducted a series of tests extending over two or three months to determine the effect on a gas engine's economy by preheating the charge.

It was thought that by preheating the charge not only could the compression pressure be raised, at light loads without preignition, but heat from the exhaust gases could be returned for utilization in the engine cylinders.

It can be shown by thermodynamic analysis that if the charge is preheated so that the temperature T_1 at A (Fig. 1) is, say, 100 deg. F. higher than normal, the temperature T_2 at B will be more than 100 deg. F. higher than if the charge had not been heated 100 deg. F. at point A. Assuming, then, the same number of heat units added on the combustion line BC, both with and without preheating, the temperature T_3 at point C will be more than 100 deg. F. higher than if the charge had not been preheated. Evidently, then, while 100 deg. F. has been added to the lowest temperature of the cycle, more than that has been added to the highest; consequently the Carnot efficiency has been increased. This may not mean, however, that the actual efficiency of the engine is improved, but merely the theoretical limit has been raised, giving a better chance for increase in the actual efficiency. From a practical standpoint, apparently, assuming the same energy entering the engine per charge otherwise than sensible heat, both with and without preheating, the only gain in actual efficiency will be due to better combustion because of the higher temperature.

THE ENGINE

The engine used for the tests was of the vertical two-cylinder, four-stroke-cycle type, built by the Bruce-Macbeth Engine Co., and was rated at 27 b.hp., with a guaranteed continuous overload capacity of 20 per cent. It is shown in Fig. 2 and operated on city illuminating gas. The governing is effected by a fly-ball governor actuating the mixing-valve stem. This valve is so constructed that the proportions of the mixture remain constant while the quantity is varied.

The ignition current was supplied by a high-tension magneto, the timing and distribution of the spark being contained within the magneto. The timing could be varied throughout a range of 30 deg. by a shift lever at the front of the magneto.

Following are a few of the important particulars of the engine: revolutions per minute (normal), 325; cylinder bore, 8½ in.; stroke, 10 in.; clearance, computed, 22.32 per cent.

AIR HEATING APPARATUS

The air heater consisted of a 12x12x36-in. wooden box containing a 2x4x34-in. asbestos core upon which was closely wound a spiral steel spring. This spring was over 1 in. in diameter and when wound on the core formed a large heating surface over which the air could circulate freely. Referring to Fig. 3, the core was held in place by the bolts AA. The binding posts B, B' and B'' were for attaching the electric-supply wires. With connection at B and B'', current was sent through the entire coil; when at B' and B'', current passed through about three-fifths of the coil; or at B' and B, through about two-fifths of the coil. By connecting the sections BB' and $B'B''$ in parallel, a very high temperature was attainable. Through rheostats placed in parallel the temperature could be regulated within a few degrees.

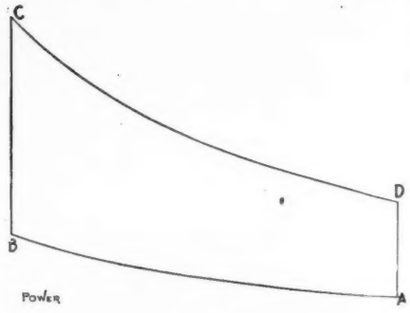


FIG. 1

Cold air was sucked into the heater through 1-in. holes at the bottom of the box; the hot air coming out at the top and passing through an orifice connected with a new style Meriam gas economy indicator used for measuring the air. The temperature of the air was taken just above the orifice and also near the engine mixing valve (see Fig. 3).

Measuring the Gas

The gas was measured by a calibrated meter and then passed through the casting of an old type Meriam gas economy indicator. This casting was simply a chamber, in two halves, joined in the middle by flanges and bolts and divided into two compartments by a copper diaphragm having an orifice ¾ in. in diameter. There is a slight difference in pressure in the gas before and after passing through this orifice, which is proportional to the amount of gas flowing through in a unit of time. This principle was used, then, as a direct-reading flow meter for the gas. For this purpose small tubes were led from the chamber on each side of the diaphragm to a sensitive manometer showing when the least gas was flowing. Very slight differences in pressure and consequently, very slight changes in the rate of flow were thus detected. After passing through the orifice, the gas passed into a small gasometer and thence to the mixing chamber.

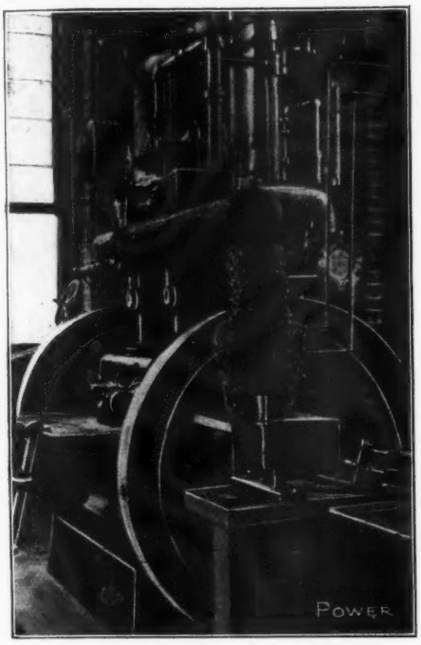


Fig. 2. Engine Rigged for Testing

Arrangement of Apparatus

Water manometers were placed at the outlet of the meter and on the gasometer. The pressure at which the gas was metered and that at which it was supplied to the engine were thus noted.

The indicators were fitted to the engine and driven through a specially constructed reducing rig, the motion being derived from an eccentric placed on the crankshaft between the flywheel hub and the end housing.

A prony brake was used to measure the delivered power. Thermometer cups were inserted in the gas pipe just above the mixing valve, in the inlet and discharge cooling water pipes, in each exhaust pipe leading to the manifold, and two in the air line, one just above the orifice casting and the other just outside the mixing valve. A water meter was placed on the cooling water discharge line.

Methods of Making Tests

Each test of the series was run at one load, and was divided into runs, each run at a different temperature of the entering air. Only the air was heated, the gas being mixed with it before entering the cylinder. The runs reported were from 1 to 2 hr. long, the longer runs being at light loads. Except the second set of runs, those at a given load were all made the same day, with the engine run continuously throughout the several runs.

The engine was allowed to run from ½ to 1 hr. at the desired conditions before the data were taken. On some of the runs, data were taken for 3 hr. and only those for the 2 last hours of the run were preserved. This was because during the first part of the run trouble was experienced from backfiring, which was accompanied by a greater gas consumption. The cooling water was always at about 66 deg. F. at the inlet and the valve on the water line was adjusted to keep the outgoing water at 120 deg. F.

Before starting each run, the gas and air throttle was adjusted to give the best possible economy. An old style Meriam gas economy indicator was used as already described, to indicate the position of the mixing valve and spark advance which gave the best economy under the different conditions. This meter was not used to give the actual flow of gas, but only to indicate when the minimum flow was obtained. The new style Meriam gas economy indicator, which was used to measure the air, was carefully adjusted to the zero point before each run.

Heat Value of the Gas

The calorific value of the gas was obtained by a Junker's calorimeter; the method of sampling the gas was as follows: Where the gas pipe enters the building, it divided, one part going to the engine and the other supplying other services. To get a continuous sample, a bunsen burner was allowed to burn on the line serving the building, while the engine was in operation. Almost an hour before the last run of the day was finished, the calorimeter was set up and by the time the tests were finished, the observers were ready to use the calorimeter; several determinations were made and the average taken. The lower heat value of the gas thus obtained was used.

Conclusions

From these tests only one conclusion is possible. The efficiency of this engine under these circumstances was not materially increased. Some interesting things will be noted, however, by referring to the summarized data sheet. Among these is the decreased speed of the engine, resulting, perhaps, from a change in the length of the mixing-valve stem, due to expansion on account of the change in the temperatures of the mixture around it. Noticeable also is the increased volumetric efficiency. This, however, is to be expected because of the increased volume of the charge due to the preheating. Another interesting thing, which also was to be expected, was the decreased power of the engine when the charge was heated. This is explained in that the temperature of the charge was increased, making the weight of the charge per stroke less; hence the heat added per unit of time and the amount transformed into work were less.

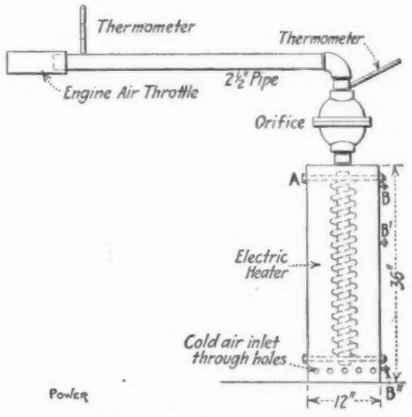


Fig. 3. Air-heating Apparatus

SUMMARIZED DATA

Run No.	Air Temperature Deg. F.	Average volumetric eff. from Indicator Diagrams	Air used cu.ft.	R.p.m.	Gas per hour cu.ft.	B.t.u. per B.hp. hr.	B.hp.	Efficiency
1-a	101.6	77.5	5,175	325	331.5	9,564	20.00	27.1
1-b	152	85.9	5,775	318	327.0	9,641	19.57	26.9
1-c	197.1	91.3	6,150	313	323.3	9,690	19.25	26.8
2-a	103.4	46.4	2,055	325	232.5	11,963	10.65	21.7
2-b	175.2	50.7	2,415	323.5	231.8	11,862	10.65	21.84
2-c	244.4	47.5	2,610	325	231	11,942	10.60	21.7
3-a	101.5	28.8	945	327	174	18,884	5.04	13.75
3-b	176	31.6	1,050	324	168	18,379	5.00	14.1
3-c	252	31.9	1,260	324	162.5	17,778	5.00	14.6
4-a	101	59.8	4,215	322	284.3	10,472	14.85	24.8
4-b	153.3	64.5	3,960	322	282.5	10,435	14.85	24.8
4-c	206	64.2	3,900	322	281.5	10,368	14.85	25.0
5-a	103	92.4	6,645	305	380	8,894	23.5	29.2
5-b	192	94.8	6,473	295	373	9,037	22.7	28.2

Refrigeration Department

Principles and operation of ice-making and refrigerating plant and machinery

Troubles in an Absorption System and Remedies—III

By W. S. Luckenbach

Why Coils Show Different Frost

When one of the expansion coils fails to show the same frost as the others, the cause is likely to be due to using dull pipe cutters, when making the connections, thus not only leaving ragged edges internally for any substance to cling to and obstructing the passage of gas, but reducing the area of the pipe also. It is very important, throughout the entire ammonia system, that every pipe and nipple be examined internally before being used, as this may save the engineer much trouble later on.

If the expansion coils are all connected to one manifold with the expansion valve at one end, and the coil that fails is near the valve, the explanation may be that insufficient ammonia passes through the valve; hence it should be opened a trifle more, but if the front of the manifold or the pipes get moist it should be closed again, as the limit has been reached. It is then evident that either the gas is not evenly distributed, or the internal passage of the coil is obstructed. All liquids, gas, steam, etc., under pressure tend to travel in a straight line unless diverted by resistance. In this case nothing would divert the gas until the last fitting was reached. Under the best of management, some irregularity will exist unless a valve is placed at the top and bottom of each coil where it can be regulated to a nicety, or the coils are divided into sections (as they should be) of from two to four, according to the size of freezing tank.

If the coil still does not frost properly, it becomes a question of deciding whether to go on and get out of it all possible until the busy season is over, or to cut it out and remove the obstruction.

Irregular Pulling of Ice Cans

Regular draws should be made for numerous reasons, especially when distilled water is used. The cans cannot be put back until enough water is distilled to fill them, and lifting them out may lower the brine enough to expose the top row of expansion coils, thus shortening the life of the coils by excessive corrosion; also, by reducing the height of the brine in the entire bath below the top of the water in the cans, the freezing is retarded. Even with enough distilled water to fill the cans at once, the excessive draw will give water at a higher temperature, with accompanying ill effects.

Pulling Ice When Rich Liquor Requires Strengthening

Under these circumstances ice can be pulled without much, if any, loss if anhydrous or liquid ammonia is injected. Connection should be made directly into the expansion coils. The drum should be a trifle higher than the coils and the ammonia admitted at intervals until the amount required has been obtained. Knowing the exact amount needed is often important, especially toward the end of the season. Suppose the rich liquor has weakened from 26 deg. Baumé to 24, the necessary amount may be determined as follows: Referring to the standard table giving percentages of anhydrous in aqua ammonia will show that at 26 deg., 28.6 per cent. is anhydrous and at 24 deg., 24.2 per cent., a loss of 4.4 per cent. by weight. With a charge of 15,000 lb. at 26 deg., 28.6 per cent. or 4290 lb. is pure anhydrous. A loss of 4.4 per cent. would require that 188.76 lb. of liquid ammonia be added to bring the charge to 26 deg., if that amount can be got in the machine without distilling.

Sometimes using aqua ammonia instead of anhydrous is preferred. As 28.6 per cent. is anhydrous, 71.4 per cent., or 2.5 times as much is water or

$$188.76 \times 2.5 = 471.9 \textit{ lb.}$$

making

$$188.76 + 471.9 = 660.66 \textit{ lb.}$$

of 26-deg. aqua ammonia, or practically one drum to be added.

Presuming the machine has its full charge at least as much water must be drawn out as will be pumped in with the aqua ammonia, which in this case would be 472 lb. at 10 or 12 deg. Baumé. This is done by distillation and will cause scarcely any decrease in the pulling per hour. First the generator should be filled as full as possible without causing a boiler-over. Then the ammonia pump should be stopped and the poor liquor valve at the generator closed. When the generator pressure is down to, say, 40 lb., some may be drawn and tested; if it is not down to 11 or 12 deg. the steam should be continued until that point has been reached. The valve on top of the analyser or rectifier should be closed and the amount required drawn off, then from the drum a charge should be pumped until the liquor is up to its usual height, and as soon as the ammonia gage registers enough to prevent the poor liquor in the cooling coils running back into the generator, the poor liquor and gas valves should be opened and the machine started. The maximum time required should not be more than four hours. With this method only the amount of liquor in the generator is distilled.

When pumping from a drum on the floor, the pump frequently fails to lift the liquor after the drum is half empty. This may be caused by too much space between the valves and plunger and the warm ammonia, but, anyhow, it is better to elevate the drum a few feet above the pump. The pipe leading from the top of the drum to the pump is thus longer than the internal pipe and when once the air is excluded in the vertical pipe it becomes a siphon and will empty the drum.

Traces of Ammonia in Ice

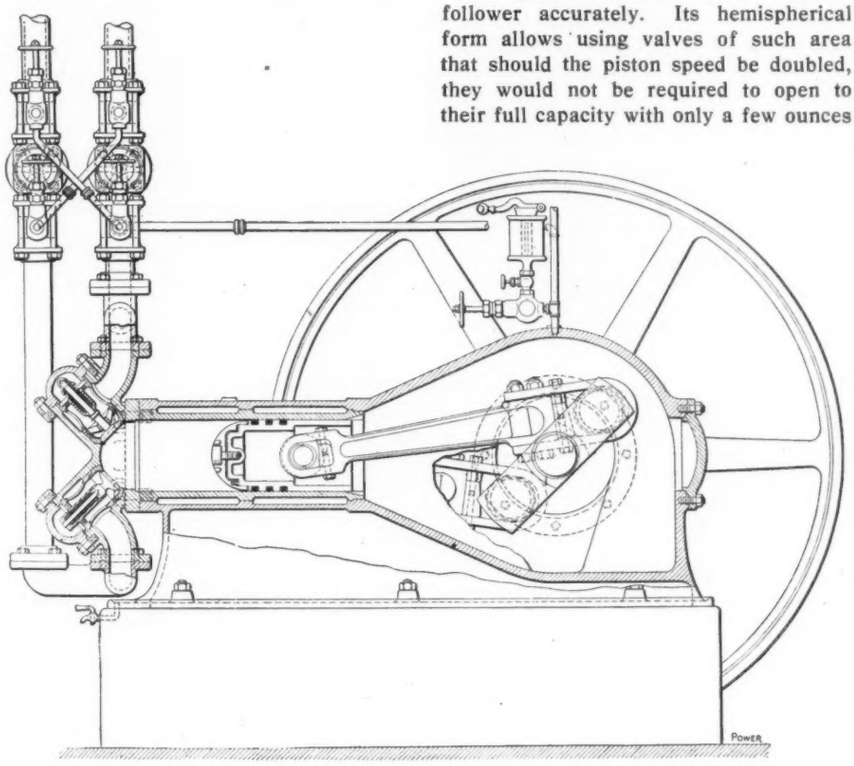
This will rarely occur if the engineer daily inspects the plant, not neglecting the distilled and raw water. The first move is to test the water at the can filler with the standard solution for that purpose. Next, if a forecooler is between it and the distilled-water tank and the water is free between them, it shows that the return gas coils or pipes passing through the forecooler leak. If there is no bypass for such an emergency the machine must be shut down until the proper connections have been made. This will increase the temperature of the water in the forecooler; hence these repairs must be made as speedily as possible. An increase of 5 deg. F. is equivalent to losing one ton of ice per 24 hr. on a 60-ton machine. The addition or abstraction of 1 deg. in temperature is approximately equivalent to 1 B.t.u. per lb. of water. Hence an increase of 5 deg. would mean the loss of

$$60 \times 2000 \times 5 = 600{,}000 \textit{ B.t.u.}$$

The standard for one ton of refrigeration per 24 hr. is 284,000 B.t.u. and for one ton of ice approximately double that amount, or 568,000 B.t.u. This leaves 32,000 B.t.u. for losses by radiation in the freezing tank and meltage when removing ice. The importance of attending to these seemingly unimportant details is thus apparent.

National Ammonia Compressor

As arranged for belt drive, the National duplex ammonia compressor is herewith illustrated; direct drive can readily be substituted. The design departs from the usual inclosed-crank type in being horizontal, for which the following advantage is claimed: All important strains being horizontal, the compressor may be placed on any floor without imparting vertical vibration to it; hence a concrete foundation is not necessary. The pistons, piston pins, crankpins and main bearings are splash lubricated. The discharge valve is near the bottom of the cylinder, facilitating the discharge of foreign matter and the liquid ahead of the gas, a factor in favor of long life and smooth operation at high speed. The machine being duplex further assures smooth operation; one piston always acting against compression keeps the crankshaft against the bearing opposite the cylinder and prevents any reciprocating motion of the shaft and the consequent strain on the packing when the bearings become worn.



LONGITUDINAL SECTION THROUGH COMPRESSOR

The shaft is a single forging of large proportions, turned down smaller where the wheel fits, thus avoiding the necessity of bushing the wheel should it ever become necessary to take a cutoff where the shaft runs in the bearings or stuffing-box. The bearing heads have interchangeable babbitt linings, oil wells and oil-return channels from the outer end and below the bushings back to the crank case.

The connecting-rods are crucible-steel castings of I-section with a strap crank end and a solid piston end. The piston-pin bearing, fitted with wedge adjustment, is cast-iron ground and lapped to fit the case-hardened and ground piston pin. The crankpin bearing, also fitted with wedge adjustment, is cast steel and babbitted.

The piston is trunk type, with three snap rings near the closed end. The clearance is adjusted by screwing the steel follower either on or off the piston proper; it is locked by a screw in the center. A coil spring actuated pin, inserted in both the follower and center screw, engages with any one of a series of countersinks so that neither the follower or screw can turn except by force.

The cylinder head is bored to fit the follower accurately. Its hemispherical form allows using valves of such area that should the piston speed be doubled, they would not be required to open to their full capacity with only a few ounces difference in pressure inside and outside the valve.

The suction valves have cast-steel safety collars, between the steel seat and cages, which also act as bearings for the lower ends of the valve stems. The weakest part of a stem is above the collar, but if it failed it could not fall into the cylinder. The valve cages are ground into the heads and held in place by the valve caps.

The cylinders are cast separately of hard close-grained iron, machined, tested to 500 lb. hydraulic pressure and pressed into the frame. The frame complete with all heads in place is again tested to 400 lb. hydraulic pressure and 300 lb. air pressure.

The water jacket surrounds the cylinder for a length sufficient to cool the compressed gases but not to warm the forward end of the cylinder. All heads and flanged joints are made male and female with lead gaskets. Studs and through bolts are used wherever possible. The suction and discharge pipes have cross-connections; the crank case is connected with the suction pipe and also with the oil trap, so the oil that works through can easily be returned to the crank case.

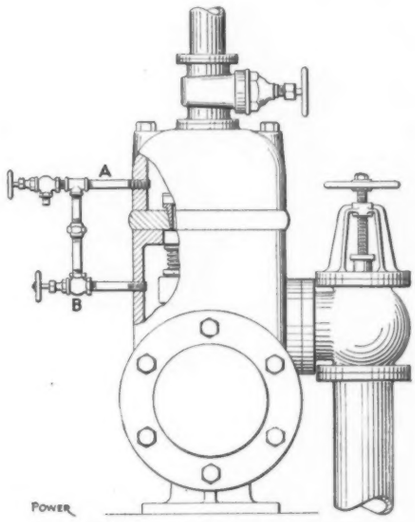
The ball-and-socket ring-oiling type outboard bearing rests on a substantial pedestal and is adjustable with setscrews to take up wear and maintain alignment.

These machines are built in sizes of from 3 to 25 tons capacity by the National Machine Co., Milwaukee, Wis.

CORRESPONDENCE

Arrangement of Priming Pipes

The illustration shows an arrangement of priming pipes put on two brine pumps that had an 18-ft. lift and used brine of 1.240 sp.gr. It works satisfactorily and has saved much annoyance to the engineers in charge when priming, after having had the pumps shut down for examination, or packing.



PRIMING PIPES ON BRINE PUMPS

The priming pipes *A* and angle valve *B* connect the space below the suction valves with the discharge chamber. The top valve is used for purging out the air, and the lower one for filling the suction chamber to the inlet valve with brine when starting. The pump should be started with the lower valve open. The suction valve should then be opened slowly and the pump will pick up its brine at once. When the pump is working all right the lower valve is closed.

R. T. REZNIEM.

Brooklyn, N. Y.

Measuring the Flow of Air in Pipes

By G. G. Crewson

Some time ago, in a large mill where it was desired to make a proper cost distribution for the compressed air supplied to the various departments, the problem arose of measuring the air velocities in the different pipes. These velocities varied from 500 to 5000 ft. per minute with the air under a pressure of about 80 lb. per square inch and as dry as can be obtained in a large compressed-air system.

The pitot tube was considered to be the most convenient device for the purpose, and in order to determine the accuracy of the various arrangements, an apparatus was fitted up as shown in Fig. 1. The air was admitted to the large tank *A* through the pipe *B* and escaped through an orifice at *C*. Pressure gages showed the pressures at the pitot-tube connection *E* and at the discharge orifice. Different-sized orifices were used in each case, these having previously been calibrated and the flow per minute under a tank pressure of 80 lb. per square inch was determined as follows:

Diameter of orifice, inch	Cu.ft. of air per min.
3/8	191
1/2	340
5/8	532
3/4	765

The pitot tube was inserted in the supply pipe at a point not less than 20 diameters away from the tank or from any bend or fitting in the pipe that would tend to cause eddy currents. Various sizes of supply pipes were also used.

The two sides of the pitot tube led to an ordinary form of U-tube, and at first this feature was troublesome as difficulty was experienced in maintaining tight connections. This was finally overcome to a large extent by making a special form of U-tube with well packed connections and leads of 1/8-in. pipe.

The form of pitot tube first employed was but a piece of 1/8-in. brass pipe bent as shown in Fig. 2. The pressure side extended slightly inside the wall of the supply pipe. This form proved very unsatisfactory, giving varying results for the same conditions.

The next change was to make the velocity tube a straight pipe instead of a bent one. This projected directly into the supply pipe and was plugged at the end with a 1/8-in. hole drilled in the side facing the flow. The results in this case were but little better than before. The opening was then changed to 1/16 in. without materially affecting the observations.

Many modifications were made in the form of pitot tube used until the one shown in Fig. 3 was adopted. This tube was of brass, turned and threaded to correspond to a 1/8-in. standard pipe to the point where it screws inside of the air pipe. Within the air pipe it has the form of a wedge with a knife-edge, the edge facing the flow, hence offering little resistance. The opening through the tube and the outlet facing the flow were 1/16 in. in diameter.

These tubes were made in a number of different lengths for different sizes of pipe in order that the opening at the edge might always be near the center of the pipe. The pressure side of the pitot tube was also found to give better results if it did not extend within the pipe but was just flush with the inside.

With this arrangement very accurate results were obtained. At one time, with velocities ranging from 500 to 5000 ft. per minute and in pipes from 3/4 to 2 in. in diameter, an average of 50 observations showed, when the velocity was calculated by the formula $V = \sqrt{2gh}$, an average error of less than one-half of 1 per cent. and a maximum error in a single observation of less than 2 per cent.

As explained, this arrangement was first used with an ordinary U-tube but as this can give instantaneous readings only, and in many cases the flow to be measured was very irregular, a recording differential-pressure gage was substituted. By this means records could be kept of the flow of air to any department over any length of time. Line leakages were also quickly detected by means of this record.

For pipes of 1 1/4 in. diameter and larger, the brass velocity tube was screwed directly into the wall of the pipe, but for smaller sizes standard ties were used, the upper branch being plugged and the plug tapped to admit the pressure and velocity tubes. The tee was then filled with lead and drilled to correspond with the diameter of the pipe with which it was to be used.

In applying this arrangement to an air line, two conditions must be met in the connections leading to the U-tube: First, all connections must be perfectly tight. Any leakage, particularly on the velocity side, due to the small opening, will introduce a large error. Every joint should be carefully tested with a soap solution for leakage and if a bubble is observed the joint should be made tighter. The second condition is to have the connections come from the top of the air pipe or, if from the side, have them pitched up at first so as to drain any entrapped water back into the air pipe. If these two conditions are observed, the U-tube or differential-pressure gage may be placed at some distance from the tube connections.

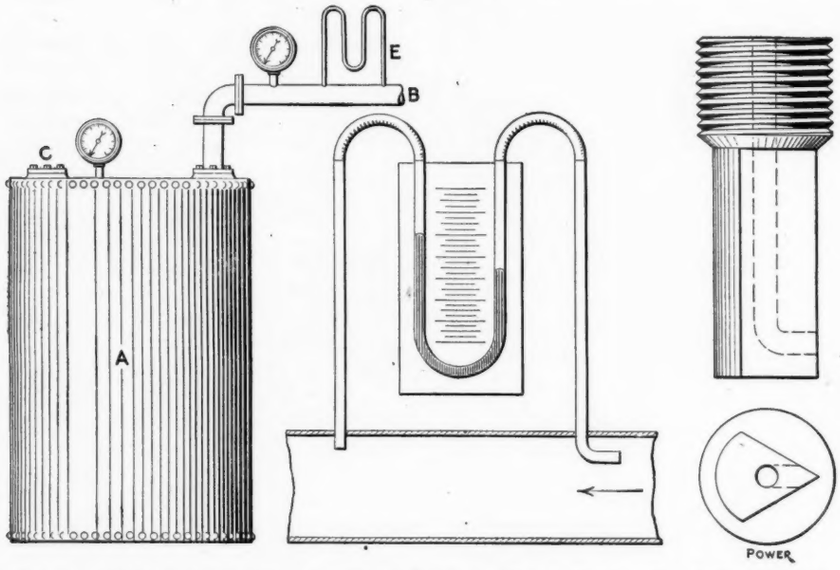


Fig. 1. Arrangement of Apparatus

Fig. 2. First Form of Pitot Tube Used

Fig. 3. Final Form of Velocity Tube

Transmission of Small Water Powers

The present day is one of very large hydro-electric transmission schemes, but in France small water powers have been successfully utilized.

A typical rural hydro-electric scheme is that of Cotentin, on the banks of the River Saire. In this installation the energy in the fall, only 15 to 20 hp., is transmitted over a maximum distance of 4 1/2 miles. During the day the output of the generating plant is utilized to run dairy machinery and at night the current is switched on to lighting circuits.—*Scientific American.*

Recently the city council of Chicago passed an ordinance requiring certain electrical equipment to prevent damage by electrolysis.

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POWER

Technical Museums

To an industrial people the history, development and present state of their industries is of more than sentimental interest. Inspiration is derived, directness of thought and effort fostered, and duplication of research and endeavor avoided by well preserved records and the intelligent exposition and exhibition of processes and products.

Across the water, industrial museums are not uncommon. Scotland has one at Edinburg, England one at London, France one at Paris, Bavaria one at Munich.

In general, the exhibits are historical and educational. The full-sized object may be displayed, or a model to some desirable scale. These are frequently arranged to be operated electrically or pneumatically or by hand. The models, working or stationary, are usually shown sectioned in their essential features, so that their movement is made plain. A brief description, with or without references to standard works on the subject, accompanies the exhibit. Good photographs and drawings are used, generally when the object itself cannot be shown or is not yet illustrated by a model.

We Americans are proud of the progress we have made in a technical way, and we have had world leaders in such lines. But we cannot afford to rest upon our laurels. We must equip our country with additional means of study and information, aiding our engineering and technical schools and presenting to a larger number of our citizens an interesting and concrete opportunity for acquiring knowledge.

Our National Museum is in Washington, and has many visitors each year; but it has not technical exhibits to compare with those abroad. It is not at all what it should be, and is available to only a very small proportion of our people.

England has a fine technical museum; the area of the country is about 58,000 square miles. Scotland has its technical museum; its area is about 30,000 square miles; Ireland has a similar museum and its land is about 33,000 square miles.

The United States comprises 2,870,000 square miles. Except nine of the Eastern states, each one contains 30,000 square miles or more. Many of the states do not have the density of population of the three foreign countires named, but are growing rapidly. In these forty-eight states are universities, supported more or less by the state. All of these can use to advantage such technical museums. Museums in connection with them would be nearer to the people of the state than the national one, and would soon become centers of attraction.

Some universities may not feel the need of such museums at present, but will in the near future. Others already desire them, but lack funds for proper displays. Many have now small beginnings of such exhibits scattered about the different buildings. With a fine technical museum at hand, such objects as are frequently desired in the class or lecture room could be duplicated; others could be visited in the museum.

The English, Scotch and Irish museums are run independently. Each has its mechanicians who make models to scale, and usually only one of each kind. Very seldom is a duplicate made and sent to another museum. If these museums cooperated, each set of mechanicians might make three models, reducing the cost *pro rata* and making the exhibits in all three more complete.

Avoiding this condition, our National Museum could take the lead for this country and help each state acquire a fine technical museum. For example, its director could have his mechanicians make working models say of Newcomen's engine, in lots of 50, 40, 30, 20 or 10, according to how many other museums might wish them, so reducing the cost to each. Similarly the mechanicians already employed in some of the universities peculiarly qualified to make some certain model could be engaged to make them for the various museums. The cost of the models would be paid to the National

Museum and its running expense not increased much by the plan.

If power to follow some such plan is not already in the hands of the director of the National Museum, Congress can pass a bill giving him the necessary power.

In fact, Congress might be willing to grant financial assistance to each state in the building of a proper, fireproof museum for technical purposes. It already allows aid in certain lines, so a precedent already exists. Such museums could be built for the cost of one battleship, and it might be that the interest aroused and stimulated in some of our future citizens by these museums would prove in an emergency of more practical value for offense and defense than the present battleships.

We would suggest this matter of technical museums to our citizens generally, our technical workers, our manufacturers, our farmers, our engineers, our university faculties, our state and national legislators. It would be an excellent thing for the organization of university presidents, already in existence, to urge the necessary measures for carrying out such plans.

Law and Common Sense

It is well to be law-abiding, but one can be punctilious. The Massachusetts law accrediting boiler inspectors employed by insurance companies, provides that they shall be examined and approved by a board of examiners. If a man fails, he may appeal and be examined by another board. Except in cases of such appeal he must wait ninety days before he can try again. If he ceases to be employed by the same company his license lapses; he cannot work for anybody else as a boiler inspector in Massachusetts without a license, and the law says "ninety days must elapse between examinations" so that he cannot get another for three months.

The ninety-day provision in the law, especially as taken in connection with the similar but more specific provision for examining engineers, was obviously intended for the applicant who had tried and failed. An inspector who is stickler enough to apply it to the case of an insurance inspector who has lost his job because his company has gone out of business, is capable of some of the fool questions and decisions, to charges of which we have listened with a reluctant ear.

Low Pressure Steam Tables

For many purposes the steam tables as ordinarily printed are not divided finely enough in the low-pressure section where the values change much more rapidly than in the higher pressure ranges. Some idea of this may be gathered from the following table:

DIFFERENCES IN VALUES BETWEEN

		1 and 2 lb.	100 and 101 lb.
Temp. deg		24.32	0.8
Sp. vol., cu. ft. lb		59.5 1	0.041
Density, lb cu.ft		0.00276	0.0021
Heat of liquid, B.t.u		24.2	0.8
Heat of evap., B.t.u		13.6	0.6
Total heat, B. t.u		10.6	0.2
Internal energy	evap. B.t.u.	16.2	0.6
	steam B.t.u.	8.	0.2
Entropy	water	0.0422	0.0009
	evap	0.0996	1.0017
	total	0.0574	1.0008

The values differ much less per degree of temperature between the lower and higher temperature ranges, but a difference of one degree makes a difference of nearly 0.2 in. of mercury at 150 deg. and of nearly 0.06 in. at 100 deg. In condenser work the lower range is usually given, not in even degrees, but in inches of vacuum or pounds of absolute pressure, which seldom coincide with the pressures corresponding to the even temperatures for which values are given in the tables. Interpolation is tedious, difficult and unsatisfactory. A table was demanded which would give the properties of steam for each tenth of a pound pressure, and even tenths, at least, of inches of mercury. These, with the intermediate values given by the even degrees of temperature, make a table from which one can find a value so nearly corresponding to that for the conditions in hand that interpolation will rarely be necessary.

Such a table, prepared especially for POWER by Prof. Lionel S. Marks, one of the compilers of the Marks-Davis steam tables, appeared in the issue of July 16, and we have received many pleasant recognitions of the service rendered by its publication. So many of those who have written have expressed a desire for these tables in a form that can be inserted in the volume of steam tables that we are forced to comply with their desires, and the tables will shortly be available in the shape of an eight-page pamphlet of the size of the Marks-Davis book.

An Eight Hour Day

A law recently passed by the Louisiana legislature limits the working day of stationary firemen to eight hours.

It has been the practice in large power plants in all states to operate with three eight-hour shifts, largely influenced by the engineers' and firemen's organizations rather than by the power-plant managers' desire to benefit their men.

It may be contended that the legislature is meddling with the rights of individuals in limiting the hours a fireman shall be employed, and that the law will work a hardship on the owner of the small steam plants who operates his factory ten hours daily. Under this law, he must either reduce the working hours in the factory or employ two firemen for the day's run.

But there is another way of looking at this question. Some states and cities have passed laws prohibiting all who cannot pass a satisfactory examination from operating steam boilers and engines. The object is not to protect them or the plant owner, but the public, which, as a whole, had nothing to do with this legislation.

For instance, a fireman having a proper license secures a position in a power and lighting plant, say on the night shift, which in thousands of small plants is from six p.m. to six a.m., twelve long hours. The twelve-hour day shift is longer than most men can withstand and give efficient service even under the most favorable conditions. When the heat, foul air and oily odors, dust, etc., are considered, let alone the nervous strain attendant on the care of the boilers, the objections to a twelve-hour shift are multiplied.

Such long hours will eventually overtax a man's vitality and mental endurance and unfit him to meet emergencies. On the night shift conditions are even worse because the fireman is deprived of his natural rest, and therefore is working under unnatural conditions. Even under the most favorable surroundings, there comes a time when the brain does not act promptly, and men in such a state are not fit to cope with sudden accidents.

Why, then, should not laws be passed preventing employers from compelling their engineers or firemen to work beyond a certain safe limit?

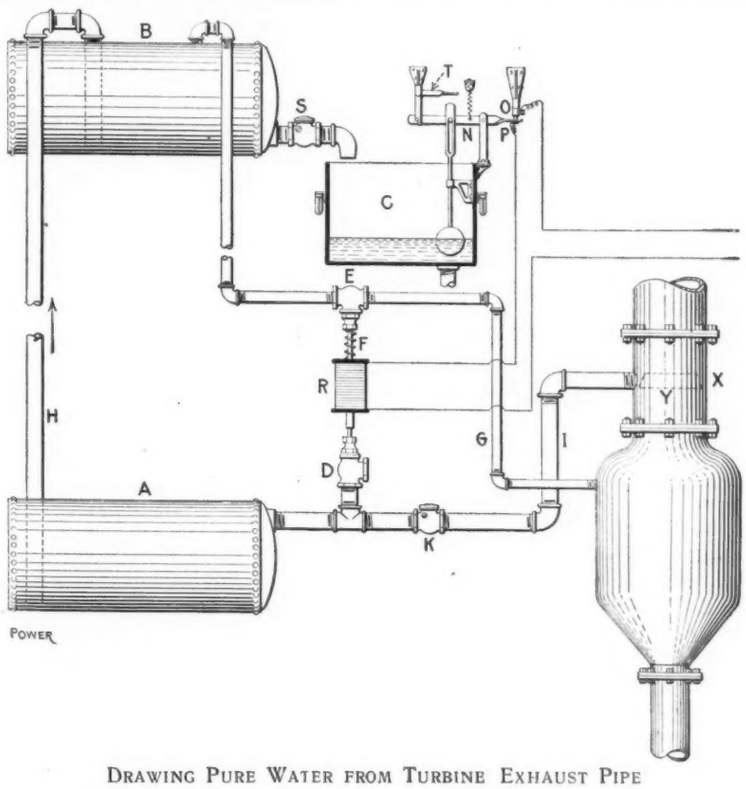
Readers with Something to Say

A letter good enough to print will be paid for. Ideas, not mere words, wanted

Pure Water from a Jet Condenser

In a turbine plant equipped with jet condensers considerable trouble was experienced with the bearing glands, due to scale-forming matter contained in the sealing water. To obtain a supply of pure water for this purpose, as well as for house use, the apparatus illustrated herewith was devised.

In the exhaust from the turbine it was thought that there would be considerable moisture running in a thin sheet along the inside wall of the exhaust pipe. To test this a strip of sheet copper was rolled into a ring of ogee section and bolted to the inside of fitting *X*, so as to form a projecting ring ½ in. wide to catch the water. A hole was tapped in the fitting at the bottom of this ring, and a pipe containing a valve was connected to a small tank. Upon opening the valve and equalizing pressures in the tank and condenser the former was soon filled with water. The apparatus indicated in the illustration was then constructed.



DRAWING PURE WATER FROM TURBINE EXHAUST PIPE

Tanks *A* and *B* have capacities of 60 gal. each, and tank *C*, made of galvanized sheet steel, is open. Pipe *G* is ¼ in. diameter and choked to $\frac{3}{16}$ in. to prevent air entering the condenser rapidly enough to impair the vacuum. At the plant this pipe leads directly to the air pump. The valve in this line is a ¼-in. globe with a loose disk, the collar nut being bored deeper to give the disk $\frac{3}{32}$ in. lateral movement on the stem. The latter can pull the disk from its seat, but cannot push it back, as the travel of the stem is limited to $\frac{1}{16}$ in. by a collar inside the bonnet of valve *D*. The disk is provided with wings working in guides in the valve body to insure proper seating of the valve. Pipes *H* and *I* are 1 in. in diameter. The operation is as follows:

With the condenser in working order, tank *C* full, valve *E* held open and *D* closed by spring *F*, air will be drawn through pipe *G* until a vacuum is established in tanks *A* and *B*. Water will then flow through pipe *I* and check valve *K*, filling tank *A* and pipe *H* to the level of the ogee. When the water in tank *C* reaches its lowest level, the float through lever *N* brings contacts *O* and *P* together, thus closing the circuit through magnet *R*, overpowering spring *F* and opening valve *D* to the atmosphere. Atmospheric pressure in tank *A* forces the water up pipe *H* into tank *B* until the bottom of pipe *H* in tank *A* is uncovered, when air rushes up pipe *H*, breaks the vacuum in tank *B* and continuing through pipe *G* forces the disk of valve *E* to its seat, thus cutting off communication to the condenser.

The weight of water in tank *B*, which is now under atmospheric pressure, opens the check valve *S* and water flows into tank *C*, raising the float until the end of the slotted float rod strikes the latch arm *T*. This releases contacts *O* and *P* so that magnet *R* is deënergized and spring *F* opens valve *E* and closes valve *D*. A vacuum is then created as before, and the operation is repeated.

The capacity of the system is limited by the time taken to fill tank *A*. The installation described furnishes about 200 gal. per hr. Tank *B* was placed about 20 ft. above tank *A* and a pressure of 4 lb. is obtained at the turbine. This seems to be sufficient to seal the bearings perfectly, although the manufacturers recommend a pressure of 15 lb. or more.

The only attention required by the apparatus is an occasional grinding of the check valves, which are of the globe variety, and the removal of rust from the piping, which forms rapidly, due to the frequent admission of air. Brass pipe would, of course, eliminate this trouble.

JAMES L. PIVENS.

Albuquerque, N. M.

Accidents Due to Water in Cylinders

In accounts of engines going to pieces they are usually either being started or shut down; but the explanation as to the cause or precautions taken to prevent a similar accident is regrettably meager.

The first engine I saw wrecked was a 500-hp. cross-compound condensing, direct-connected to a 400-kw. generator, running at 150 r.p.m. It was the engineer's second year on a Chicago license, and this was his first engine. The steam pressure was 160 lb. and the exhaust went to a main exhaust line of about 3000 hp. capacity and was about half loaded. The vacuum on the engine was about 26 in.

There was a horizontal receiver between the two cylinders having a 1-in. drain cock near the bottom with an extension stem running up through the floor. There was no floor in the basement, and water would rise up around the receiver foundation after a rain. It had been raining considerably prior to the accident, and the water was up even

with the top of the drain. As the engine had no atmospheric exhaust, the stop valve leading into the main exhaust line had to be opened before the engine could be started.

The engineer opened this valve and then cracked the throttle and started to close the drain. Just as he stooped down there was a clap in the low-pressure cylinder on the head end and the connecting-rod doubled up like a jackknife. The solution was simple. The water flowed through the drain into the receiver and then into the cylinder; the exhaust valve closed and the entrapped water did the damage.

I have seen locomotives stalled by running into a flock of sheep and getting the wool wound into the crankpin boxes. Years ago I made a stop one night to replace a broken crankpin-wedge bolt in a triple-expansion 1000-hp. pumping engine. After the bolt was tightened, the chief opened the throttle, and as the low-pressure engine came to the crank center there was a loud report and the low-pressure crosshead parted just back of the wristpin.

I concluded the cause was this: He closed the throttle and dropped the knock-off cams on both the intermediate- and low-pressure cylinders (the high pressure was the only one hooked to the governor), and the flywheel and what steam was left in the cylinders and receivers carried the engine around a few more revolutions. This allowed the vacuum in the low-pressure receiver to drop considerably. The pressure when running was about 18 lb. absolute.

He closed the river cock and put on the forced injection so as to have the jet condenser cool when he made the start. The condenser was 10 ft. above the river. It filled and, as the cylinder pressure was less than atmospheric, the water backed up and when the engine was started the exhaust valve closed for compression and the water was "squeezed."

Some years later, the connecting-rod on the same engine was bent to an angle of about 15 deg. when making a start from a dead stop. After the pumps had gained their suction and the engine came up to speed, the reach rod loosened from the wristplate, due perhaps to its not being properly latched. This let the receiver pressure drop and, as it had some water in it, the cylinder "took a drink."

I was oiler on a lake steamboat when we got a hot crankpin shortly after we cleared. Everybody was more or less excited, as we were in a bad place to stop and the wind was blowing a gale. The majority of the passengers were sick and nervous and when the engine stopped they thought they were going straight down. Water backed up into the low-pressure cylinder, and when we started the valve was forced back from its seat, bending the stem so badly that the cylinder was useless until the stem was removed and straightened. The second engineer was handling the engine while the chief and fourth engineer stood by to put the shims in between the crankpin brasses. He left the forced injection water on too long and it backed up, doing much damage. We had to put back to port.

No engine can be made foolproof, but an engineer should take every precaution, if he can get the necessary money, which is about half the work.

I have put atmospheric checks on all low-pressure receivers and checks in their drain pipes, a good trap on all intermediate- and low-pressure receivers and a tee in place of the ell running to the jet condensers. I have a hinged valve on this tee that can be worked from the operating stand. As soon as the engine comes to a stop I open this valve and close it as soon as the engine turns over a few times.

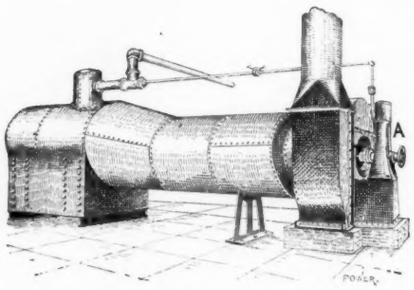
SAM H. FARNSWORTH.

Chicago, Ill.

Stationary Locomotive Boiler Test

Railroads, when they need a stationary boiler, are accustomed to use an old locomotive boiler stripped of its running gear, and with a steel stack 40 to 60 ft. high.

These boilers do not prove very satisfactory, as the horsepower developed is much below that obtained on the road. At a certain railroad roundhouse, a water-softening plant was installed and my job was to set the boilers. I long had a notion that by proper erection these boilers could do better, and proceeded to put my idea in practice.



LOCOMOTIVE BOILER FITTED WITH INDUCED DRAFT

I concluded to set this boiler somewhat as it was designed to be set, and operate it as it was intended to be, by leaving in the baffle-plates, exhaust nozzles and brick firebox arch. I took down the stack, closed the opening and cut one in the bottom of the extension front, and connected an induced draft fan, as shown at *A* in the illustration. Then a baffle-plate was put in to equalize the draft through the flues (the draft being from the bottom, the baffle was the reverse of what it would be when the draft was at the top). A brick arch was put in and the boiler fired up. The improvement was so marked that a test was run to determine what the boiler would do.

The efficiency was highest when the output was greatest and the uptake temperature highest. The uptake temperature was lower when the draft was 1.73 in. than when it was 0.59 in. This was probably due to the scouring action of the gases when passing through the flues and that the gas was swirled, and had no hot core. Note, 255 hp. with 16 sq.ft. of grate and 1 hp. per 3.42 sq.ft. of heating surface.

TEST RESULTS OF LOCOMOTIVE BOILER HEATING SURFACE

Firebox	87.7 sq.ft.		
Tubes	792. sq.ft.		
Total	879.7 sq.ft.		
Grate surface	16. sq.ft.		
Duration of test	3 hr. 59 m.	2hr. 51m.	1 hr. 33m.
Draft in water	0.59	1.09	1.73
Steam pressure lb.	99	97.9	101.
Temperature feed water deg.F.	57.6	57.5	58.
Temperature flue gas, deg. F.	830.	756.	802.
Total coal burned, lb.	2,400.	2,800.	2,000.
Coal burned per hour, lb.	602.	984.	1,290.
Combustible burned per hour, lb.	454.	742.	973.
Total water evaporated lb.	12,418.	15,812.	11,374.
Water evaporated per hour, lb.	3,117.	5,548.	7,338.
Factor of evaporation.	1.2		
Water evaporated per pound coal, lb.	5.17	5.65	5.68
Water evaporated per lb. coal at 212 deg.F.	6.20	6.78	6.82
Water evaporated per lb. combustible at 212 deg.F. lb.	8.22	9.00	9.04
Coal burned per sq.ft. grate per hour	37.4	61.5	80.62
Horsepower developed	108.	193.	255.
Sq.ft. heating surface per hp.			3.42
B.t.u. per lb. coal	9,550.		
Percentage of ash	13.7		
Efficiency	62.8	68.5	68.9

I have installed induced draft on about a dozen such boilers, with highly satisfactory results.

E. J. SAXE.

Christopher, Ill.

Results in CO_2

You have urged the engineer to purchase a flue-gas analysis instrument and keep pace with modern engineering practice and you print, from time to time, "highbrow" articles about it, and then let the matter drop. You offer indicator diagrams for criticism, and I venture to say that 60 per cent. of your readers examine them and all unconsciously figure how they could be improved.

Why cannot the flue-gas analysis be worked from the same standpoint? Having given a certain size boiler, grate and load, with gas analysis, draft and flue-gas temperatures and firings, and a certain grade of coal, criticize the results obtained, suggest how they can be improved with ideas as to how to fire, and how the draft and air supply should be regulated. To start the ball rolling I send, herewith, some results taken from a hand-

fired 350-hp. Babcock & Wilcox boiler for criticism.

HARRY A. COX.

Middletown, N. Y.

350 H.P. B. & W. Boiler — 76.5 sq.ft. grate area
Coal No. 1 Buckwheat — Avg. Load 225 Boiler H.P.
Temp air - 80° F. — Avg. Steam 145 lb. gage.

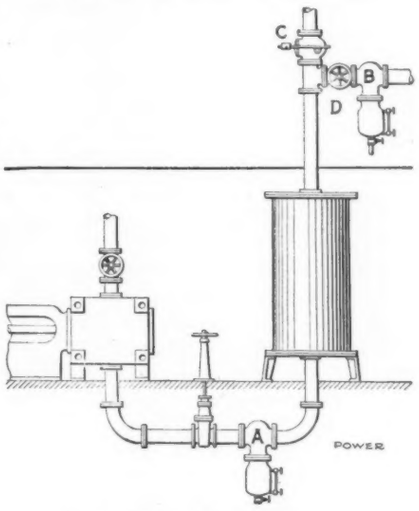
Time	CO_2	Draft at breeching	over fire	Flue gas Temp	Remarks
9 a.m.	11.8	0.39	0.33	380	Damper ¾ open
9:05	11.2	0.40	0.34	385	
10	14.0	0.29	0.22	395	Damper nearly closed
15	11.6	0.38	0.32	395	
20	13.9	0.39	0.33	395	
25	14.0	0.39	0.33	410	
30	15.1	0.22	0.15	405	
35	13.0	0.37	0.31	405	
40	14.6	0.36	0.30	408	
45	7.0	0.52	0.46	420	Damper wide open. Cleaning fire.
50	13.4	0.51	0.45	415	
55	5.4	0.50	0.45	425	Cleaning fire.
10—	11.0	0.50	0.45	425	
05	13.8	0.43	0.37	417	
10	11.6	0.41	0.35	405	
15	15.8	0.40	0.34	402	
20	11.8	0.38	0.31	397	
25	13.1	0.20	0.13	390	
30	11.0	0.41	0.35	402	
p.m.					
7:15	14.0	0.36	0.30	397	Avg. Load 375 Boiler H.P. Steam pressure 151 lb.
20	14.0	0.40	0.34	410	
25	5.0	0.34	0.28	400	Fire door open Temp. air 73° F.
30	12.0	0.39	0.33	415	
35	12.6	0.52	0.46	415	
40	16.1	0.51	0.46	415	
45	16.4	0.51	0.46	430	
50	15.1	0.51	0.46	440	
55	15.8	0.44	0.38	445	
8—	12.1	0.56	0.50	420	
05	16.6	0.53	0.47	440	
10	13.6	0.53	0.47	445	
15	15.6	0.50	0.44	436	
20	12.8	0.48	0.42	425	
25	12.4	0.51	0.45	435	
30	13.4	0.51	0.45	437	
35	12.2	0.56	0.50	430	
40	14.6	0.51	0.45	435	
45	13.0	0.52	0.46	430	

A Misplaced Separator

A recent inspection of the plans and specifications for a large addition to a power plant showed the oil separator between the engine and the heater. One reason for this design is that the exhaust steam will be purified before it goes into the heater, and the latter, if of the closed type, will not be made inefficient by the accumulation of sediment from cylinder oil. Another point in its favor is that steam condensed in a closed heater may be returned to the boilers. A separator, however, will do better work if placed beyond the heater. Drops of water in the exhaust steam after it passes the heater assist in the process of eliminating oil.

The illustration shows the heater and part of the exhaust-steam piping in another power plant, in which a change has recently been made. The separator *A* was located near the engine under the floor, but when put into service it did not purify the exhaust steam. An expert steam engineer reported that the separator should be located beyond the heater, and as there was not enough head room for it in the engine room, it was located in the room above, as shown at *B*. When the engine is exhausting to atmosphere, steam does not go through the separator, but if it did there would be less grease on the roof.

During cool weather the back-pressure



LOCATION OF OIL SEPARATOR

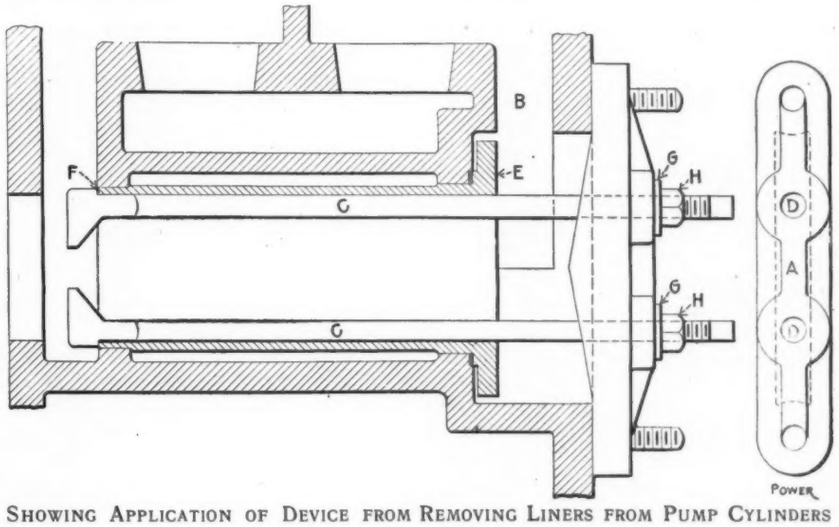
valve *C* is closed, and *D* opened, so that all exhaust steam goes through the separator, is delivered to the heating system free from oil and can be safely pumped back into the boilers.

W. H. WAKEMAN.

New Haven, Conn.

Device for Removing Water Cylinder Liners

The removal of liners from the water cylinders of pumps is usually a troublesome job, especially if the liner is stuck fast as it often is.



SHOWING APPLICATION OF DEVICE FROM REMOVING LINERS FROM PUMP CYLINDERS

This trouble can be avoided and their removal made easy by the use of the device shown. The casting *A* is slipped over two studs after the cylinder head has been removed as at *B* and then the two pull bolts *C* are pushed through holes *D* in the casting and made to engage the back end of the liner *E* as at *F*. The washers *G* and nuts *H* are then tightened to hold the bolts in place. By screwing up on the nuts the liner can be started and thereafter easily removed. The device may also be used to drive the new liner in place.

W. H. WOLFGANG.

Toledo, Ohio.

Care of Electric Elevators

In the plant under my charge there are three electric passenger elevators having motors operating under 220 volts. As I am not very familiar with electric elevators, will some interested reader tell me, through POWER, the best way to manage and care for them?

What I particularly desire is an explanation of the counter-balancing of elevators in general, a brief enumeration of the chief sources of trouble, and the proper way to avoid them in electric elevator operation.

L. A. TROWBRIDGE.

Cambridge, Mass.

Doubts Economy of Uniflow Engine

It seems impossible to me that this type of engine can run with economy at any load either condensing or noncondensing. To those who understand its economical features, I would ask a few questions:

Why does excessive compression give more economy with this engine than with others? Why does this engine show better results with overloads than others? What good is a condenser except to reduce the exhaust pressure, and if it is of advantage to reduce this pressure, why is it not the opposite to increase it?

L. JOHNSON.

Exeter, N. H.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Cotton Rope Drive

A. Rauch has been particularly unfortunate in his experience with cotton rope drives, as related in the July 2 issue.

From the figures he gives the conditions should be favorable to a very satisfactory drive. Surely something must be abnormal when his ropes will not run three weeks without breaking. It would be a help in diagnosing the trouble to know what horsepower is being transmitted by each rope.

I once had a cotton rope drive which gave out in 12 months. The velocity was about 5000 ft. per min., and the ropes were 1½ in. in diameter. These ropes were put on during structural alterations and became filled with lime and cement dust. After 12 months we removed them and put on another complete set of 1½-in. four-strand cotton ropes. The last time I saw this drive it had been running nine years and the ropes were still in good condition.

I am with a firm having a number of mills, one of which is driven with 112 cotton ropes which have been running four years. Fifty of these ropes are now overloaded and are being replaced by cotton ropes of slightly larger diameter, as the pulleys will permit of this change without overcrowding the grooves.

I once had trouble with one 1500-hp. drive which had 1½-in. cotton ropes running at 7000 ft. per min. These ropes used to jump the grooves, apparently because their period of vibration synchronized with the beat of the engine. We eventually corrected this by putting on 1¾-in. ropes These were rather large for the grooves but pulled down after a few weeks' work.

I have never had the misfortune to have to stop after six hours' run to tighten ropes. We have had to tighten them after a week's run but that tightening lasted for years. Mr. Rauch should look into his drive again, because, from his figures, there is nothing to prevent his getting a satisfactory life out of cotton ropes We have many thousand horsepower transmitted by cotton ropes and I have not come across a similar experience to Mr. Rauch's. If he can give any further information it might help us to avoid such trouble as he encountered.

My experience is that 10 to 15 years' service can be had from ordinary cotton ropes under normal conditions.

I have had no experience with manilla ropes nor with the American continuous cotton-rope drive; our drives are all parallel.

JOHN GILLEAN.

Paisley, Scotland.

Another Experience

The foreword in the July 9 issue reminded me of my own experience.

I was only about 18 years old at the time I took charge of my first plant, which consisted of an old 60-in. by 16-ft. boiler, and an old rattle trap of an engine about 14x20 in. The whole plant was very dilapidated, and, in addition to burning all the shavings and refuse from the mill, sawdust and wood from an adjacent sawmill were used.

I first cleaned the boiler, which was very badly scaled from using feed water carrying a high percentage of lime. All the other plants in the neighborhood used some boiler compound, but the owner of this one would not furnish any. "It cost too much and was no good anyway," he said. After knocking off all the scale I could by hand, I made a feeder, and began using a weak solution of lye made from wood ashes, as a water softener.

Next, I reset the valves on the engine and packed nearly every joint, valve and rod on the place; cleaned the boiler tubes and combustion chamber, as well as the heater, and then began to see some results.

Some three weeks later, after we had cut off the extra fuel from the sawmill and were running on our own refuse, the owner saw me sitting in the doorway reading POWER. I was apparently at ease with the world. "Well!" said he, "You sit around more than any other man on the job; haven't you anything to do?" "While I am sitting here I am not shoveling fuel into the furnace, and you have that much less to pay for," I replied. The conversation immediately shifted to the state of the weather, and I spent a good many pleasant hours' reading and studying in that same doorway without any further interference.

The next plant had a somewhat larger engine equipped with a Meyer cutoff valve. The proprietor, in showing me around, paused in front of the mysterious little handwheel at the back end of the steam chest, and assuming an awed air, told me to "never, never change that wheel; it is set just right and must never be changed." However, I found out in a few days that several turns of that same wheel in the proper direction would save lots of work with the scoop, so I made what changes I wanted without consulting him. But even then, the work was so hard that I turned it over to another engineer with more muscle.

There are many owners of this type in charge of small plants and I have found that the only way of dealing with them is to be independent, and insist on having absolute charge of the plant, or else leave it to others willing to put up with that kind of treatment.

F. P. READ.

Memphis, Tenn.

Remedy for Unequal Cutoff

LeRoy Whitney's trouble cited in the July 9 issue is likely caused by a bent or worn governor connection.

The eccentric also appears to be too far back, causing a late admission and wire drawing the steam even at slow speeds. I would suggest that he set the valves all over again, checking each part, and fitting on a new block and catch if necessary to hold the head-end valve open during the stroke with the governor on the block. When this is done it will be simple to apply the indicator and equalize the cutoff.

J. M. COLEMAN.

Ipswich, Mass.

Oiling a Prony Brake

The account of a prony brake test, given by Alan A. Slade in the Apr. 16 issue, reminds me of a similar experience with a 60-hp. tractor.

The brake pulley was hollow, 34 in. in diameter, with an 11-in. face. The shaft was mounted in roller bearings and a 6-ft. beam was used. As Mr. Slade suggests, the parts were made as light as was consistent with safety. The brake band was made of hard maple blocks set so that the wear came parallel to the grain. The pulley had a water-feeding device and a scoop for removing the water as it heated.

Although the brake was water-cooled it heated excessively, evidently being overloaded. A one-pint glass-body sight-feed oil cup was arranged to deliver oil directly to the face of the pulley. In addition a ¾-in. hole was bored in the frame and a mixture of lard oil and graphite dropped on the pulley face at

regular intervals. With this regular oil and graphite lubrication very satisfactory tests were made, though we got a great deal of steam from the interior of the brake pulley. It was much easier to keep the beam balanced when oil was used.

This brake has since been supplanted by an electric dynamometer which we find is a very successful testing machine.

C. V. HULL.

Charles City, Iowa.

Valve Motion and Rods of Duplex Pump

If N. H. J., who asks questions on page 69 of July 9 issue, will turn to POWER for Apr. 5, 1910, page 646, he will find those questions answered fully. If he will then draw a diagram of a duplex valve motion having both valves driven by a lever of the same class, he will see how impossible it is for a pump to work with the form of valve movement of which he inquiries.

When pump rods wear and turning them down seems necessary, do not forget that these rods must be packed. Do not turn them so that a 5/8-in. packing is just too large and a 9/16-in. just too small; turn to a definite size. If the pump is a duplex do not turn the rods different sizes as is sometimes done. It means continual trouble for the man who does the packing. Just use a little forethought and find the smallest place on each rod. Take the smaller of the two measurements and fix upon a diameter that it will be possible to fit with packing. Then turn both rods alike.

WILLIAM E. DIXON.

Malden, Mass.

Shorter Cutoff Greater Load

Concerning the article on the above subject on page 180 of the issue of Aug. 6, my idea is as follows:

Assume an engine to be running with an average load that is constant, with the receiver pressure just equal to the terminal pressure in the high-pressure cylinder.

If the cutoff in the low-pressure cylinder is shortened, the receiver pressure rises, because the low-pressure cylinder is not taking from the receiver as great a volume of steam as is being delivered to it by the high. The receiver pressure is then higher than the terminal in the high and a diagram from this cylinder will loop. The loop represents negative work, and to make up for this, the engine will slow down to a certain extent, thus lengthening the cutoff in both cylinders, with a tendency to still further raise the receiver pressure. On shortening the cutoff again practically the same results would occur, and so on.

To make the argument more clear, we will assume the high-pressure cylinder capable of taking steam full stroke. Then if we keep shortening the cutoff in the low, the receiver pressure will continue to rise, and the cutoff on the high continue to lengthen until full stroke is reached. Boiler pressure will then exist in the receiver, or will when the volume at cutoff in the low is equal to the total volume of the high. Then with a short cutoff in the low-pressure cylinder, with boiler pressure for the initial pressure, we can see that this cylinder could carry practically all the load.

While we have been shortening the cutoff in the low, the governor has been lengthening the cutoff in both cylinders, and the low pressure would have all the load with the governor running in a lower plane. If we had an engine designed for a cutoff up to 3/4 or 7/8 of the stroke, as most long-range cutoff engines are, and desired to put all the load possible on the low-pressure cylinder, we could shorten the cutoff on it until the high-pressure cutoff neared its limit. The governor would then revolve in a lower plane, having less range in admitting more steam and a wider range to reduce the cutoff in both cylinders. This would probably not be a satisfactory manner in which to operate an engine of this kind, but is intended only to show that the load can be shifted from one cylinder to the other in a very marked degree, by altering the cutoff in the low-pressure cylinder.

I may be wrong in my belief on this matter, and no one will be better pleased than myself to be shown wherein lies the error or errors in my argument, as this is a question on which many engineers are hazy and which they are anxious to understand thoroughly.

JOSEPH STEWART.

Hamilton, Ohio.

Hoarding Knowledge Hinders Progress

I think the foreword under this title in the June 11 issue was very timely and contained good advice. I have often heard people criticized for "giving their ideas or brains away."

If an engineer or mechanic knows a little kink or improvement that will help someone, it is more to his credit to give it out freely than to keep it to himself, thus "hiding his own light under a bushel," so to speak. But if he feels he ought to be paid for it, he does well to publish it.

He at least has the satisfaction of feeling that he has not had his trouble for nothing and it may do some other fellow good. By being generous in small things he gains later on in large ones.

GEORGE J. LITTLE.

Passaic, N. J.

Exhaust Steam Turbine

The possibility of increasing the electrical output of a small- and medium-sized power plant, without correspondingly increasing the steam-generating equipment, by installing exhaust-steam turbines, is of great general interest to all operating engineers.

POWER'S editorial of July 2 suggests a golden opportunity for wide-awake, progressive engineers to prove to their employers that they are worthy of the consideration and remuneration due the man of ideas and initiative.

Were you to be called upon tomorrow by the "old man" to advise him as to how your power plant might best be increased in capacity; could you discuss the subject intelligently? Could a low-pressure turbine be used advantageously in the plant under your charge? What definite, specific facts, backed up by actual cost figures have you to present to substantiate your arguments? If you have not gone into the subject, you may be missing one grand chance for advancement.

The low-pressure turbine is not a cure for all power-plant ills. It may not work out as worth while in your case. While you may convince yourself that to use a turbine is advisable, you will probably be unable to induce the boss to agree with you in your conclusions. Take a chanee. Work it out. Your assumptions, figures, and conclusions, and even perhaps the reception accorded your suggestions by the boss, might be of sufficient interest and educational value to warrant publication in POWER. In which event your labors will have a triple value. First and foremost, the careful consideration of an engineering problem of this character will be of value to any engineer. Your findings may prove of value to other engineers, and finally you will receive a monetary remuneration for your effort, even though, perhaps, not directly through the boss.

A paper mill in New England has just installed a low-pressure turbine to more fully utilize the exhaust from an overloaded Corliss engine. The layout of the plant made it possible to substitute several motor drives for considerable shafting and belting. The results obtained are most gratifying to the owners. A very considerable increase in power was made with no increase in steam-generating capacity. Regrettably, installing the low-pressure turbine was suggested, not by the engineer, but a consulting engineer called in to prepare plans for extending the boiler plant.

A remarkably inexpensive and apparently efficient condensing plant is used in this installation. The condenser is of the so-called ejector type. Injection water is supplied by a steam turbine-driven volute pump. No dry vacuum pump, or vacuum pump of any kind is used, yet

a steady vacuum of 28 in., as indicated by a mercury column, is being regularly maintained. As a simple test showed that the ejector will raise its water supply 20 ft. automatically, the power required for operation must be very low.

The use of this simple type of condenser for high vacuum is proving a source of comment to many engineers who have visited the plant.

JOHN W. BRUCE.

Holyoke, Mass.

Taking Chances with Boilers

F. J. Naylor's experience with a defective boiler, as related in the July 23 issue, reveals how some owners will take chances with defective boilers, thereby endangering the lives of their employees, to say nothing of the loss of property that might result from an explosion.

Some inspectors are very slack, or worse in making inspections. In a large mill where I was employed as assistant engineer, I noticed one morning an unusual activity on the part of the chief engineer and his helpers. I inquired into the cause, and found that the boiler inspector was coming the next day. The fire pump which had been out of commission for four days was repaired, and a month's accumulation of soot was cleaned from the boilers and everything fixed up as presentable as it could be. The next morning, which was Sunday, three of the five boilers were cut out and cooled down. The inspector came into the boiler room dressed for entering the boilers, asked the chief a few questions, felt of one of the boilers, said they were too hot to enter and went out. On the following Monday night a gage-glass broke on one of the inspected boilers. They had to send out to another mill to get one. The fireman tried to locate the water with the gage-cocks, and on finding them plugged with scale, cut the boilers out and pulled the fire. One machine had to be shut down. He was promptly fired the next morning.

The boilers were inspected that way for about two years, when one Sunday morning a stranger stepped into the boiler room and stated that he was an inspector. The chief called up the owner and he came down, but the inspector refused to be bluffed, and things began to happen right away. He said it was the worst boiler room he had visited in two years. The steam gages were tested, two of which were defective. He refused to let them run the boiler until perfect ones were obtained. He forbade them running one of the boilers until retubed. When the old tubes were removed there was a mass of a sort of porous scale from the second row of tubes from the bottom up to the third row down from the top. He stayed in town three days, and when he went away the chief said he hoped he never would come again. But he did, and always without any warning, too. The result was things were kept in better condition. The chief or owners were not far-sighted enough to see the saving which resulted, and were always complaining about how strict the inspector was.

V. C. WOOD.

Copenhagen, N. Y.

Explosion of Air Receiver Due to Oil

The writer of the article which appeared under the above caption in the July 30 issue is evidently firmly convinced in his theory that the receiver failure was due entirely to the ignition of the oily coating on the inner surface of one head and the consequent weakening of that head. In presenting this theory, however, he neglects to furnish the details of construction that would permit calculations showing whether the receiver was safe for the pressure carried.

That thousands of air-pressure receivers are in use under the same conditions as stated makes it imperative that before entering into any theorizing on oil ignition, the safe working pressure of the received should be carefully ascertained.

The statement that rivets ⅜ in. in diameter were used to fasten the head to the shell seems sufficient to arouse suspicion that the receiver was structurally weak for the pressure carried, and the photographed head in Fig. 4 has the appearance of an ordinary flat head, or, of being bumped to a much larger radius than the pressure would warrant. If this is true, and the head that failed was similar and flanged inward, the cause is apparent.

If this oil-ignition and combustion theory has any tangible basis every air reservoir carrying 100 lb. pressure or more is likely to explode at any moment, no matter how strongly it may be constructed. Therefore, I would urgently request Mr. Richards to send in the following data on the receiver's construction: material, thickness of shell plates, type of joint, pitch of rivets, thickness of heads, and radius to which the heads were bumped.

The article states that the receiver was constructed "with dished heads; the convex side of the head was outward at one end, and the concave side outward at the other end, which is the too common practice, just for convenience in riveting in the last head, and for no other good reason." This leads me to ask the writer what other way he can suggest for fastening the heads of small receivers, also what objection he has to this form of construction, if the heads are made of proper material and thickness, and bumped to the proper radius, or stayed as the conditions may require.

JOSEPH KING

Lynn, Mass.

Plant Economy

W. J. Bailey's letter under this heading in the issue of May 21 interests me. While the most economical plan for his plant cannot be determined without more data, it would seem that the procedure contemplated would be a move in the wrong direction for the desired results.

I would suggest that the whole plant be run at 150 lb., and that the high-speed units be run condensing and also other steam-driven equipment, the exhaust of which is not needed for heating. The exact economy in coal depends on a number of conditions; in fact, the cost of water may make my suggestion entirely impracticable, but in any case I should not attempt to run the engines with 75 lb. back pressure, or the pumps at 75 lb. pressure if more pressure is available.

L. JOHNSON.

Exeter, N. H.

While Mr. Bailey's intended experiment appears interesting, I cannot see how any saving could result or the plant be any more economically operated. By keeping 85 to 90 lb. steam pressure and operating the engines, air compressor, and pumps from the same header (which I am sure is of ample size, being 14 in. in this case) he can get full service from all the units, at a minimum cost for packing, upkeep, lubrication, fuel and a hundred and one other things that will give absolute satisfaction under 100 lb. pressure, but certainly would give trouble under 150 lb. pressure. Moreover, reducing valves would then be unnecessary.

Under his plan considerable condensation can occur between the power units and the air compressor and pumps which, by the way, are the meanest of all engines I have ever had anything to do with, to operate with wet steam. This condensed steam could be handled very well by installing separators of sufficient sizes, but a steam separator is a device to take wasted energy from that which may be utilized; hence another waste. Then, I would not think it wise to put an engine designed to operate at 100 lb. pressure where it would have to operate at 150 lb. If I tried such an experiment I would expect results not very pleasing to the boss.

As Mr. Bailey does not say how he intends to operate the air compressor and pumps when the power units are not running, and as he says he will have a specially designed back-pressure valve to relieve No. 3 boiler if the pop valve proves too small in case of overloads, there is evidently no intention of firing this boiler after it is converted into a "receiver."

P. T. BARKER.

Stonega, Va.

Inquiries of General Interest

All Questions Must be Accompanied by Name and Address—Not for Publication

Percentage of Slip in Motors

Why must an induction motor operate with slip, and is there the same percentage of slip in all sizes of motors?

H. E. H.

In an induction motor, the current is induced in the rotor by the latter cutting the rotating field flux. This would not be so if they were in exact synchronism, as no current would be induced; therefore no torque would be exerted and the motor would not run. The amount of slip of induction motors varies with their size. In large motors of 200 to 300 hp., the slip may be as low as 1 per cent., while in 1-hp. motors it may be as high as 20 per cent.

Free Air Capacity

What is meant by the free air capacity of an air compressor or a blower?

J. E.

As commonly used the term refers to the number of cubic feet of air at atmospheric pressure and ordinary temperature received per minute for the operation of compression or delivery in form of forced draft.

Width of Keyways

What is considered good practice for the width of keyways for shafting?

E. J.

Make the width of the keyway equal to one-fourth the shaft's diameter.

Instruments Required For Boiler Trial

What instruments are required for making an evaporative trial of a boiler?

Scales for weighing coal and ashes; tanks or "liquid weighers" for gaging or weighing the feed water; thermometers and pyrometers for taking temperatures of air, steam, feed water, waste gases, etc.; steam-pressure gages and draft gages; and a colorimeter for determining the percentage of moisture in the steam. Local barometric pressure of the atmosphere at the time of making an evaporative trial should be known. In addition to the instruments mentioned a hydrometer for determining the amount of moisture in the atmosphere and apparatus for analysis of flue gases are highly desirable for studying the character of combustion, although these are not as essential for conducting an evaporative trial as they are to determine whether conditions were favorable or unfavorable for obtaining best results.

Glass Gages on Vertical Boilers

What is the proper height to set a water gage-glass on a vertical boiler?

H. H.

Vertical fire-tube boilers of ordinary proportions should have their water columns or glass-gage fixtures set at such a height that the lowest visible part of the glass gage will be not less than one-third the length of the fire tubes above the lower tube sheet.

What Pressure for Receiver

What pressure should be carried in the receiver of a cross-compound condensing engine 12x22½x18 in. (i.e., cylinder ratio 3.51), the initial pressure being 110 lb. and the vacuum 26 in.?

F. A. F.

In addition to the data given it is necessary to consider the desired distribution of load between the two cylinders (generally equally distributed), the point of cutoff and back pressure of the high-pressure cylinder. See "Equal Work in Compound Engines," by F. R. Low, in POWER of July 18, 1911, pages 88 to 91.

Cast Iron Fittings for High Pressure Steam

Are cold-water pressure tests sufficient to warrant the safety of cast-iron fittings and appliances against rupture when used for high-pressure steam?

M. D.

No, such tests may be sufficient to reveal blow-holes or cold-shut castings, but will not determine whether rupture is liable to result from changes of form due to changes of temperature as well as from pressure, nor afford assurance of strength to resist distorting reactions of expansion or contraction of connected piping and other appliances. As a material of construction, cast-iron is proverbially treacherous, and when fittings and appliances made from it are employed in high-pressure work they should be regarded as hazardous until thoroughly tried out for their especial purpose and situation.

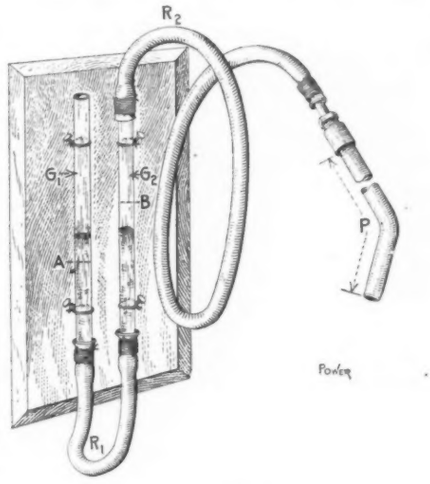
Measurement of Force of Draft

How is the force of a flue or chimney draft measured?

W. B.

Force of draft is usually expressed in inches of water, meaning pressure equivalent to that of a column of water which would be supported by the difference between the pressure of the flue or chimney gas and the pressure of the atmosphere. It is generally measured by the difference in levels of water columns of a U-tube manometer having one end open to the atmosphere and the other in communication with the chimney flue or passage in which the force of draft is to be measured. The U-tube may be made of glass tubing bent as the letter U or improvised as shown in the illustration.

G_1 and G_2 are two ordinary boiler gage-glasses joined at their lower ends by the rubber tubing R_1. One of the columns of the U-tube as G_1 has its upper end open to the atmosphere, while the upper end of G_2 is connected by a rubber tube R_2, and a nipple to a piece of ½-in. pipe P about 4 ft. long, bent over at its open end. Water is poured into the open end of G_1 until it stands about half way up the length of both glass tubes. The open end of P being inserted in a flue or passage where the force of draft is to be measured, then as the atmospheric pressure is greater than that of the flue gas, the water is depressed in the tube G_1, as to A, and rises in G_2, as to B, the difference in levels A and B thus assumed being the height of water column due to the unbalanced force of draft. By turning the pipe P in different directions its bent open end will be presented for measuring the force of draft in different directions or parts of the flues and passages.



DRAFT GAGE

Study Questions

This Week's Questions
Last Week's Answers

(86) If a gas under constant pressure occupies a volume of 10 cu.ft. at 32 deg. F., what volume will it occupy at 212 deg. F.?

(87) How many pounds of ⅛-in. sheet lead will it take to line the sides and bottom of a rectangular tank 6 ft. long by 4½ ft. wide, holding two tons of water when filled within 6 in. of the top?

(88) A belt-driven triplex pump delivers 3.2 gal. per revolution of its driving pulley, which is 18 in. in diameter. It is to be belted to a line shaft running at 80 r.p.m. What size pulley must be put on the shaft to cause the pump to discharge 400 gal. per min.?

(89) In heating 1 lb. of water from 50 to 120 deg. F., how many heat units are absorbed by the water and what is the equivalent in units of work?

(90) An engine develops 100 hp. at 80 r.p.m. with a mean effective pressure of 36 lb. Required the diameter of the cylinder if the stroke is 3½ ft.

Answers to the above will appear in the next issue. Answers to last week's questions follow:

(81) One pound of the condensing water contains 50 — 32 = 18 B.t.u., then 36.71 lb. contains

$$18 \times 36.71 = 660.78 \text{ B.t.u.}$$

The total heat in 1 lb. of steam at 216 deg. F. (from steam tables) is 1151.9 B.t.u. Then 36.71 + 1 = 37.71 lb. of the mixture contains

$$1151.9 + 660.78 = 1812.68 \text{ B.t.u.}$$

and each pound

$$\frac{1812.68}{37.71} = 48.07 \text{ B.t.u.}$$

Then its temperature must be 32 + 48.07 = 80.07 deg. F.

(82) Atmospheric pressure at sea level is 14.7 lb. per sq.in. abs. A piston 3 ft. in diameter has an area of

$$0.7854 \times (3 \text{ ft.})^2 \times 144 \text{ sq.in.} = 1017.9 \text{ sq.in.}$$

Then the total pressure acted against is

$$14.7 \times 1017.9 = 14{,}963.13 \text{ lb.}$$

and acting through a distance of 5 ft. the work done is

$$14{,}963.13 \times 5 = 74{,}815.65 \text{ ft.-lb.}$$

(83) The diameters of the gears will be inversely as the speeds. Let

D = Diameter of the larger gear;
d = Diameter of the smaller gear.

Then

$$\frac{D}{d} = \frac{240}{192} \qquad (1)$$

Since the pitch circles will be tangent, the sum of the radii of the two gears will equal the distance between the shaft centers, or

$$\frac{D}{2} + \frac{d}{2} = 18 \text{ in.}$$

From this

$$D = 36 - d \qquad (2)$$

Substituting in (1)

$$\frac{36 - d}{d} = \frac{240}{192}$$

Simplifying

$$6912 - 192\,d = 240\,d$$
$$432\,d = 6912$$
$$d = 16 \text{ in.}$$

and

$$D = 36 - 16 = 20 \text{ in.}$$

(84) The coefficient of expansion for mild steel is 0.0000067. Then

$$0.0000067 \times 60 = 0.000402 \text{ ft.}$$

or

$$0.000402 \times 12 = 0.004824 \text{ in.}$$

is the amount each rail will expand per degree rise of temperature, and for 98 — 32 = 66 deg., the expansion would be

$$0.004824 \times 66 = 0.318384 \text{ in.}$$

which is the space that must be left between the rail ends.

(85) The unit stress developed will be

$$f = c\,t\,E$$

where

c = Coefficient of expansion;
t = Degrees change of temperature;
E = Modulus of elasticity.

For steel E is generally taken as 30,000,000. In the answer to the preceding problem, c was given as 0.0000067. Then

$$f = 0.0000067 \times 66 \times 30{,}000{,}000 = 13{,}266 \text{ lb. per sq.in.}$$

Pitot Gas and Air Meter

In order to get close readings and accurate determination the Pitot meter for measuring air or gas, shown herewith, has been brought out. It can be attached to any pipe from ½ in. up, and can be used as a portable or permanent instrument.

The meter consists of a brass tube or well, around which is wound a transparent celluloid tube, the lower end of which connects to the well; the upper end to a passage through the yoke and cock to the tube in the pipe whose opening is perpendicular to the flow of gas or air.

The well is connected by a similar opening through the yoke and cock to the pitot tube having one or more openings facing the flow of the air or gas.

Water or oil is put into the well through an opening made for the purpose until it reaches a zero mark on the helix.

When the cock handle is vertical the space above the fluid in the well and above the fluid in the helix are both open to the atmosphere, and if the fluid stands at zero under these conditions, accurate results will be obtained.

By turning the cock handle 90 deg., as shown, the well is connected with the air or gas pipe through the pitot tube and the space in the helix is connected to the same pipe through the straight tube.

If there is no velocity to the air or gas in the pipe, the liquid in the helix will remain at zero irrespective of the pressure, as the statical head does not change with the pressure where the pitot tubes terminate.

The pressure in the pitot tube when the air or gas flows through the pipe is transmitted to the well, and the liquid in the helix rises in proportion to the velocity of the air or gas.

GAS AND AIR METER

For every inch of vertical rise the liquid travels about 10 in. around the well, and as this distance is graduated in 100 parts, the head can be read to $^1/_{100}$ in.; consequently the actual velocity of the air or gas is readily determined.

The well and helix are revolvable on the yoke so that the head of liquid in the helix can always be read, yet the connection to the pipe is not broken.

Any error caused by evaporation or condensation is readily detected by turning the cock handle for an instant to a vertical position, when the liquid in the helix should return to zero if conditions have not changed.

As the helical tube is of transparent celluloid it cannot break. The meters are tested to 100 lb. pressure. They are heavily nickelplated and are manufactured by the Sargent Steam Meter Co., 136 West Lake St., Chicago, Ill.

Test of Pipe Covering

The following results were obtained on an acceptance test made by D. J. Lewis, Jr., to determine the effectiveness with which a 10-in. pipe partially exposed to the weather at the Matteawan, N. Y., plant of the New York Rubber Co. had been insulated. The pipe, which leads from the boiler house to a distributing receiver located in the mill is 346 ft. in length, 198 ft. being exposed to the outside temperature at an average height of about 25 ft. above the ground, as shown in the reproduced photograph herewith, and the specifications required that it should be so thoroughly insulated that the condensation should not exceed 0.17 lb. per square foot of interior pipe surface per hour with a temperature of 65 deg. inside the building and zero outside. The exposed portion of the line was covered with 2½-in. Nonpareil high-pressure blocks and ½ in. of Nonpareil medium-pressure cement wrapped with canvas and waterproofed.

Inside the building 1½-in. blocks and one-half an inch of cement were used.

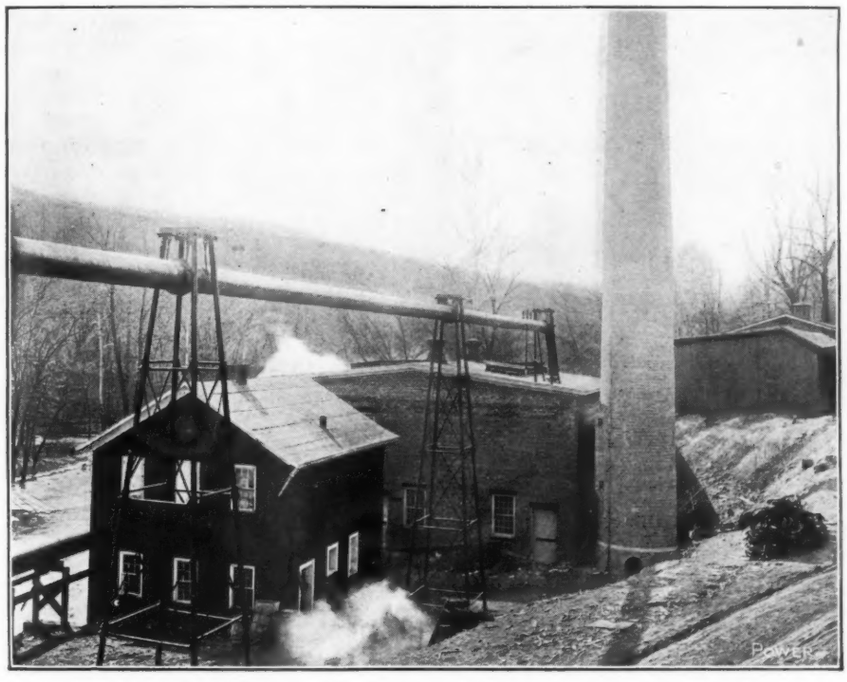
The condensation from this pipe and receiver was collected in a trap which discharged into a receptacle located upon a pair of scales. The receptacle was half filled with cold water into which the discharge pipe from the trap extended 8 in. When the water became so hot as to show a vapor it was discharged and replaced by cold water.

Simultaneous readings were taken every ten minutes of the pressure and temperature in the boiler house and at the receiver, and of the temperature of the inside and outside air. All instruments were calibrated and the test run for 4½ hours while the factory was in operation, extending from 10:15 a.m. to 2:45 p.m.

RESULTS

Square feet of surface exposed to outside temperature	517.364
Square feet of surface exposed to inside temperature	481.725
Total surface exposed	999.089 sq.ft.
Average steam pressure in boiler house	112 lb.
Average steam pressure at receiver in mill	111.64 lb.
Average difference in steam pressure	0.36 lb.
Maximum difference in steam pressure at any one reading	1 lb.
*Average steam temperature in boiler house	341.51 deg.
Average steam temperature at receiver in mill	341.03 deg.
Average difference in temperature	0.48 deg.
Maximum difference in steam temperature any one reading	2 deg.
Average temperature of outside air	27.66 deg.
Average temperature in mill	73.8 deg.
Total amount of condensation discharged by trap	568 lb.
Average amount of condensation discharged per hour	126 lb.
Average condensation discharged per sq.ft. of surface per hour	0.1261 lb.
Average condensation discharged per sq.ft. of surface per hour corrected for a temperature of 61 deg. F. in mill and zero outside	0.1361 lb.

*The discrepancy between the average temperature given and that corresponding to saturated steam is doubtless due to the lag of the thermometer.

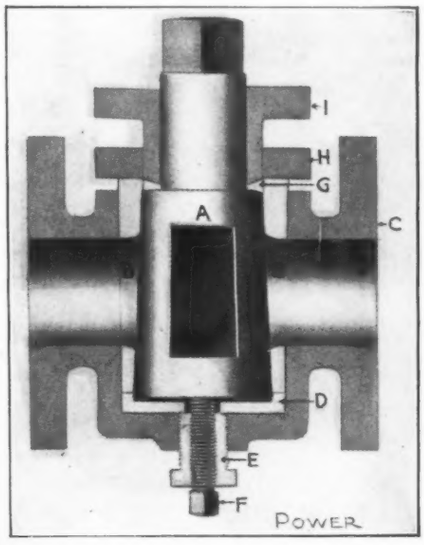


10-IN. PIPE TESTED AT MATTEAWAN PLANT OF N. Y. RUBBER CO.

A bronze bust of Joseph Henry, the distinguished scientist, has been presented to the American Institute of Electrical Engineers by Past-President Gano Dunn.

Turneasy Blow-off Cock

This plug cock consists of a body, renewable bushing and a plug *A*, which has a reversed taper with the bushing *B*. The plug and bushing are both removed from the body after taking out the glands *H* and *I*, and forcing the disk *D* up with the screw *E*. The parts are forced to a seat with the retaining gland *H*. The plug *A* is adjusted and held in position with the screw *F* to any degree of tightness. If the plug seems unnecessarily tight, the screw *F* is loosened one-quarter to one-half turn and the plug lightly driven down.



SECTION OF BLOW-OFF COCK

Wearing action takes place on the outside of the plug and on the inside of the bushing. These cocks are made interchangeable for every size, and of brass, bronze, iron or steel, as conditions require. The cock is manufactured by the Easton Tool & Machine Co., Easton, Penn.

McLeod-Mueller Turbine Check Valves

In the McLeod-Mueller nonfouling turbine check valves the disk is cast on a stem with inclined turbine wings below the disk and straight wings above, as shown in Fig. 1.

The fluid entering the inlet of the valve acts on the turbine wings and causes the stem to revolve and unseat the disk. The stem continues to revolve while the fluid is passing through, causing the straight wings to agitate the fluid above and expel all dirt. It is claimed that this valve cannot foul as the dirt is all expelled from the upper chamber by the straight wings. Another claim is that the valve cannot hang or stick because a cup bearing at the bottom, which is slotted so it cannot become packed with fluid, and a cone-shaped bearing at the top, which

conforms to the shape of the stem, act as guides to the stem and cause the disk always to seat true, and also, because the disk seats with a whirl and expels all dirt from the seat. The valve is self-grinding, since the disk rotates in seating and constantly changes its posi-

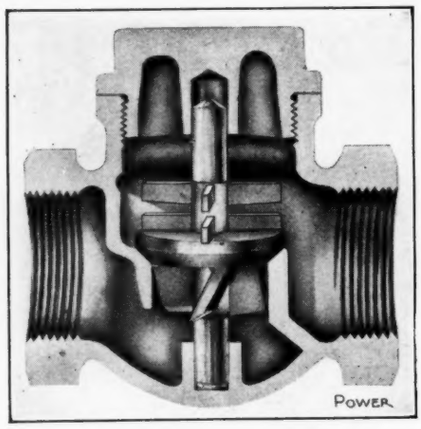


FIG. 1. CONSTRUCTION OF THE MCLEOD-MULLER TURBINE CHECK VALVE

tion. This rotation also has a cushioning effect and tends to prevent hammering and maintain a water-tight surface between the disk and the seat.

The adjustable top, shown in Fig. 2, consists of a regulating screw around which are a gland and packing that make a water-tight joint when compressed by the stuffing nut. With this adjustable top

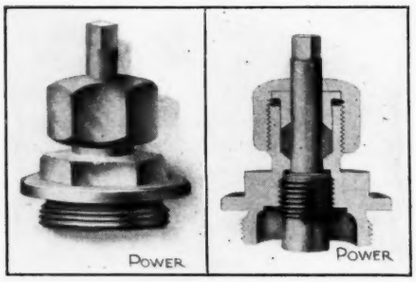


FIG. 2. DETAILS OF THE ADJUSTABLE TOP

the check valve may be used as a globe valve, and the stem can be regulated to give any size of opening desired.

This valve is made in vertical, horizontal and angle patterns, but the adjustable top can be used only with the two last. It can be used for water, steam, oil, or any other fluid of common density.

The H. Mueller Manufacturing Co., Decatur, Ill., holds the patents and exclusive manufacturing rights.

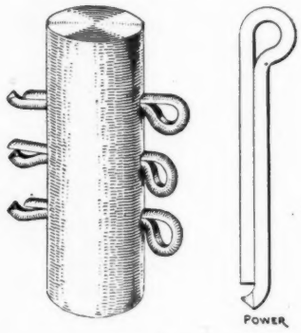
The Hess-Bright Manufacturing Co. has removed from its former location at Twenty-first St. and Fairmount Ave. to its new factory, corner of Front St. and Erie Ave., Philadelphia. The new location affords ground and floor space for much needed expansion.

New Form of Cotter Pin

To obviate the bother of spreading the tips of a cotter pin after inserting and the usual trouble incident to its removal, an improved design has been patented and placed on the market by Andrew C. Campbell, of Waterbury, Conn.

The pin, as shown, is made from a piece of half-round wire, bent so as to provide an offset eye at one end and have two limbs of unequal length with the flat sides adjacent. The tip of the longer limb is bent at an angle across the tip of the shorter limb. Hence, when the eye is given a blow, the shorter limb is driven over the longer one, and the engagement of the tips causes a separation of the limbs.

To remove the pin a screw driver or other tool having a sharp flat end, such



PIN INSERTED LOCKED AND READY FOR REMOVAL

as the tang of a file, is inserted in the eye, and by twisting it so as to expand the flattened eye, the short limb of the pin is drawn back to its original position and the pin may be withdrawn easily.

The top pin in the illustration is merely inserted in the hole; the middle one has its limbs spread by a blow on the eye; and the bottom pin is about to be extracted.

The entering point being on one limb only, this pin is easier to insert in the hole than an ordinary cotter pin. Moreover, the latter must be spread on the side of the hole opposite from that in which it is inserted, while this new pin is inserted, locked and removed from the same side, making its use possible in places difficult of access.

The Rees Roturbo Pump

In 1906 the Rees Roturbo pressure chamber pump was invented and placed on the European market. The American and Canadian rights to manufacture and sell this pump have recently been ob-

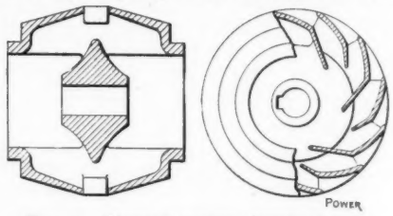


FIG. 1. SINGLE-STAGE IMPELLER IN SECTION

tained by the Manistee Iron Works Co., of Manistee, Mich.

The characteristic feature of the pump is the self-regulation of the driving power secured by making the impeller of large capacity for storing water. From the eye

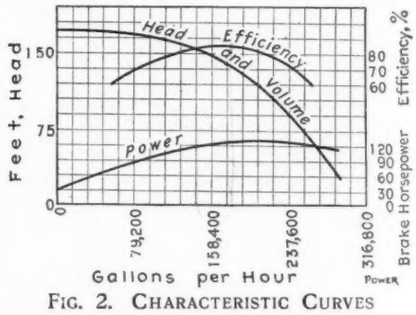


FIG. 2. CHARACTERISTIC CURVES

of the impeller the water enters the pressure chamber, which is constructed with blades, as shown in Fig. 1, and is discharged through rearwardly directed nozzles, or guides, to the external casing. In this way the water is held together and the loss from the churning

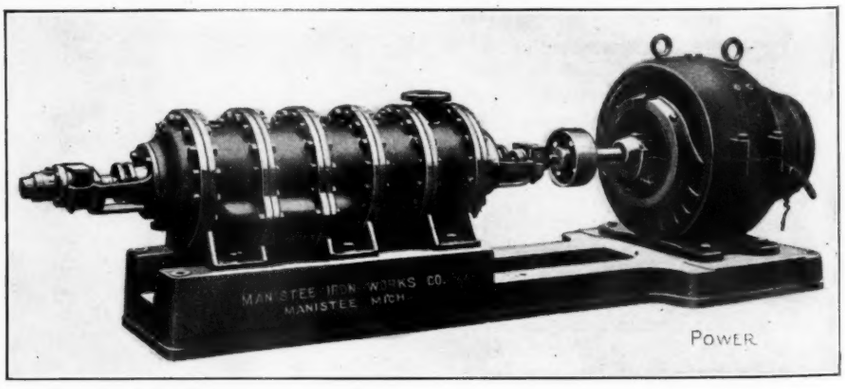


FIG. 3. LATEST TYPE OF REES BOILER FEED PUMP

action of the impeller found in pumps of early design is avoided. The reduction of the velocity of flow of the water through the pressure chamber also decreases the friction. The rotation of the impeller, together with its water, creates

a constant pressure equivalent to a certain head. A reduction in the head causes a larger volume of water to be discharged so that at a constant speed of rotation the power absorbed is perfectly constant for all heads of discharge and heights of suction possible. Thus the power required is limited and it is impossible to throw any overload, on the driving motor under these conditions. This is shown in Fig. 2. The power curve rises to a maximum at about normal head and volume. With an increase in volume the head drops off so that the power does not increase appreciably above that required for normal duty. Naturally, the efficiency is greatest at the capacity for which the pump is designed.

Fig. 3 represents the latest type of Rees Roturbo boiler-feed pump direct coupled to a continuous-current motor. The rotating parts of the pump consist of a series of pressure-chamber impellers which are mounted upon a common shaft supported upon intermediate bearings. The general appearance of these impellers is shown in Fig. 4, which gives a view of one common shaft with two impellers mounted upon it. Each of these impellers consists of two stages.

A feed pump on test is reported to have delivered 18,000 gal. per hr. against a boiler pressure of 220 lb. per sq.in. at an efficiency of 76½ per cent. Other data submitted were the characteristic curves in Fig. 2 of a comparatively low-speed pump running at 925 r.p.m. The remarkably high efficiency of 84 per cent. may be noticed. The duty of the pump is 150 ft. lift and a delivery of 158,400 gal. per hr. at the above speed, the diameter of the discharge pipe being 12 in. When this pump was tested at the works the following results were obtained:

Starting from the duty point, viz., 158,400 gal. per hr. at 150 ft. head, the power is reduced from 120 hp. to less than 40

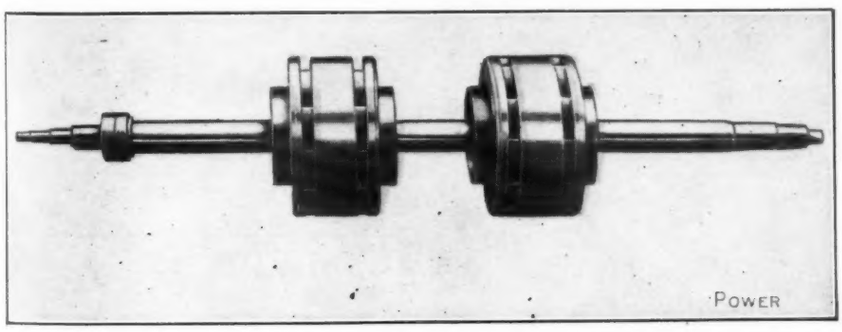


FIG. 4. TWO-STAGE IMPELLERS ON COMMON SHAFT

as the discharge valve is closed. To the right of the curve when the discharge valve opened so as to reduce the head against which the pump is working, the volume with minimum pressure is increased to double that at the normal duty, showing that there is not any throttling in the pump.

Test of Another Large Boiler

In view of the importance which has been attached to the tests of the 2500-hp. boilers at the Delray Station of the Detroit Edison Co., a test recently made by Prof. L. P. Breckenridge, of the Sheffield Scientific School at Yale, upon one of the 1250-hp. Bigelow-Hornsby boilers at the plant of the Hartford Electric Light Co., will be read with interest. This boiler was designed for a 2500-hp. unit some years before the Delray boilers were contemplated, but upon erection was divided, by the throwing up of a partition wall in the furnace and the separation of the steam drums, into two units of 1250 hp. each.

Five separate tests of about eight hours each were run, in one of which a capacity of 2245 hp. was maintained all day. The highest efficiency obtained was 77 per cent. and the efficiency at 180 per cent. of rating was 70 per cent. The tests were made with the boiler in service and with no preparation except an external blowing of the tubes and stopping of air leaks. The tubes had not been cleaned internally for more than a year. The fuel was taken from the ordinary supply, as purchased for use by the company, and was of only medium quality. A condensed table of the data and results is given herewith. A description of these boilers and the Taylor stokers with which they are equipped will be found in POWER, Feb. 28, 1911.

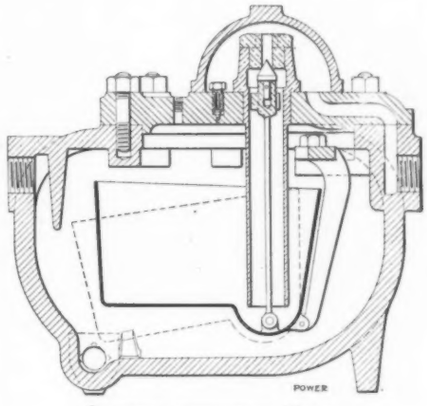
BIGELOW-HORNSBY BOILER AT HARTFORD ELECTRIC LIGHT CO.

Condensed Table of Data and Results

	Prelim.		Final		
Test No.	2	3	4	5	6
Date of trial (1912)	Feb. 6	Feb. 7	Feb. 8	Feb. 9	Feb. 10
Duration, hours	8.15	8.0	7.43	8.48	8.02
Total Quantities					
Water actually evaporated, pounds	448,048	465,527	534,349	516,369	359,285
Weight of coal fired, pounds	50,202	50,525	61,712	57,049	38,736
Weight of ash and refuse, pounds	4,485	5,228	6,039	7,265	4,373
Percentage ash and refuse in dry coal, per cent.	9.38	10.83	10.28	13.36	11.82
Moisture in coal as fired, per cent.	4.52	4.69	4.91	4.68	4.52
Pressures, Temperatures, Draft, etc.					
Steam pressure gage, lb. per sq.in.	151.8	152.3	158	153.3	152.8
Temperature of feed water entering boiler, deg. F.	211.8	212.4	213	213	213.1
Temperature of steam leaving boiler, deg. F.	450	436	431	432	433
Temperature of flue gas at uptake, deg. F.	498	526	574	535	510
Degrees of superheat in steam, deg. F.	82	69	63	64	65
Draft between damper and boiler, ins. water	0.49	0.36	0.29	0.26	0.31
Draft pressure of furnace tuyeres, ins. water	2.18	2.70	3.17	2.65	1.53
Boiler Horsepower					
Boiler horsepower developed	1,735	1,825	2,245	1,895	1,400
Percentage of rated horsepower, per cent.	139	146	180	152	112
Efficiency Results					
Water evaporated per lb. of coal as fired, pounds	8.94	9.17	8.66	9.05	9.30
Equivalent evaporation per lb. of dry coal, pounds	10.20	10.46	9.80	10.23	10.47
Equivalent evaporation per lb. of combustible, pounds	11.24	11.75	10.91	11.80	11.88
Heating value per lb. of dry coal, B.t.u.	13,630	13,787	13,625	13,280	13,280
Heating value per lb. of combustible, B.t.u.	15,250	15,180	15,100	14,870	14,870
Efficiency of boiler and furnace combined	72.7	73.7	69.8	74.8	76.5
Efficiency based on combustible	71.7	74.8	70.2	76.9	77.5

Hydromatic Steam Trap

The new steam trap gotten out by the Engineers' Appliance Co., Cleveland, Ohio, illustrated herewith, contains a bucket hinged at the lower corner. A discharge tube, in which the pole rod of the valve operates, extends from the top of the trap to a point level with the bottom of the bucket, where it is hinged by a pin. The water of condensation enters the trap through the left upper connection and, striking the baffle-plate, falls to the bottom of the trap. As soon as the water rises to the level of the bucket, it is filled and, being hinged at one end, is forced downward, which movement operates the pole rod and opens the discharge valve. The water is then forced out of the bucket, up through the discharge pipe and valve to the chamber above the valve seat and out through the discharge outlet. The bucket then assumes its original position, closing the valve. The operation is repeated with the inflow of additional water.



SECTION THROUGH TRAP

Locomotive Boiler Explosion

By M. C. St. John

A locomotive boiler explosion on the St. Louis, Brownsville & Mexico R.R., a few miles south of Bay City, Tex., killed the engineer, fireman and conductor and completely wrecked the locomotive, tender and several loaded box cars. Two views of the wreck are shown in the accompanying illustrations.

Fig. 1. Exploded Locomotive Boiler

Fig. 2. Locomotive Trucks beside the Track

The engine was running at a speed of between 25 and 30 miles an hour when the explosion occurred. The cause will probably never be known.

The boiler was thrown to one side, parallel with the track, with the front end toward the rear of the train. The trucks were derailed and after being shoved for 75 ft. by the momentum of the train were piled in a heap with the tender and six box cars. The three men in the cab were caught under this wreckage.

The cause was purely a crown-sheet failure, but whether from low water or not is not known. The crown-sheet was blown down to and below the grate line from the second row of staybolts in front on the flue sheet back to the rear end of the firebox. The flue sheet was not disturbed, or any of the tubes injured. Two rows of staybolts next to the flue sheet were intact, with the exception of a few which seemed to have been elongated. Very few staybolts were torn out of the crown-sheet, but were broken off just flush with the top of the sheet almost as smooth as if they had been sheared.

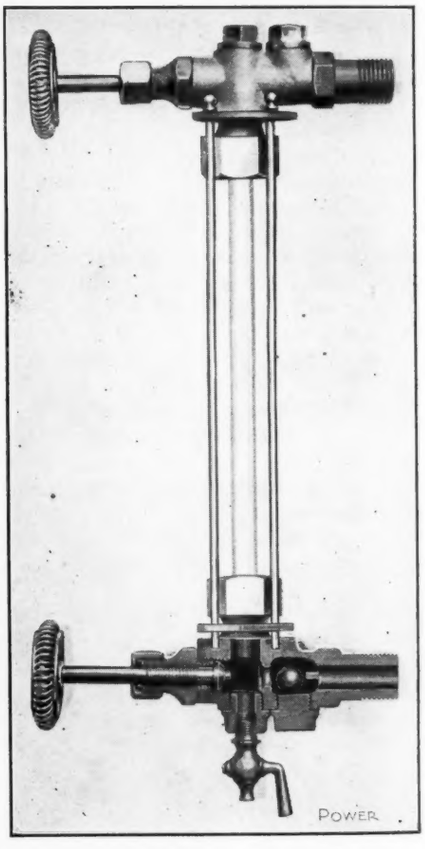
The staybolts before breaking showed indications of having stretched, in some cases, an inch or more, the diameter being reduced in section in proportion to the amount of elongation.

The boiler was an old one and had evidently seen hard service.

Watertown Automatic Safety Water Gage

This water gage possesses several features of merit aside from the ground bronze noncorrosive check balls, which, with its seats, constitute the automatic feature of the safety device.

Each ball lies in a chamber and in case the gage-glass breaks, the steam pressure acting on the upper ball and the water pressure on the lower ball forces them to their seats, automatically cutting off the escape of steam and water. When the pressure is removed the balls will fall to the bottom of the chamber. Should it be desired to shut off either top or bottom connection from the boiler by hand, the handwheels are turned, screwing the solid disks against their seats.



Automatic Safety Water Glass

The main feature of this device is its construction, which permits of accessibility to the ball chamber and to the water-glass connection, as shown in the illustration. By removing the plug from the bottom and top of the ball chamber the ball can be removed and any accumulation of sludge or scale washed out.

The pet-cock in the bottom of the water-glass connection can be removed, thus permitting of cleaning out this opening to the glass. The valves are removed by unscrewing the stuffing-box plugs which permits a straight entry to the boiler connections. The gage is manufactured by the Watertown Specialty Co., Watertown, N. Y.

SAWMILL WRECKED BY BOILER EXPLOSION

Sawmill Boiler Explosion

BY A. STALEY

On July 31, at 10:05 p.m., a boiler in the Weiner sawmill, on the outskirts of Joliet, Ill., exploded, wrecking the building and killing the night fireman, the only man on duty at the time.

This boiler was equipped with a 3-in. ball-and-lever safety valve, which, from its appearance, had not blown for a long time. The plates were $\frac{5}{16}$ in. thick and had three patches on the bottom of the shell. The boiler was 66 in. in diameter and 16 ft. long. The heads were braced with twelve ½x2-in. crowfoot braces. There were forty-four 4-in. tubes.

Employees state that the boiler was never inspected and that no insurance was carried on the boiler. Gages were never tested and the safety valve was supposed to blow at 90 lb. pressure.

It was the custom of the employees to take turns at firing the boilers at night, there being no regular fireman or engineer. The man in charge of the boiler at the time of the explosion was a new employee and had never fired a boiler before.

From all appearances it was not a case of low water, but of excessive pressure. The boiler was only supposed to be carrying between 70 and 80 lb. at the time. Pieces of the shell were scattered around the neighborhood. A second boiler was thrown about 50 ft. from its setting, resulting in a cracked girth seam on both sides of the boiler.

Trill Continuous Card Indicator

The Trill continuous card indicator is so made that a roll of paper is placed on a drum, the indicator started and a card given for every stroke of the engine without any further attention on the part of the engineer. It is attached to the engine in the ordinary way.

A roll of paper is placed on the smaller drum *D* and the free end threaded around the larger drum *E* on which the diagram is traced. To avoid the necessity of tracing a separate atmospheric line for every diagram, the second pencil *B* is provided, and set at the atmospheric line given by the first pencil, thereafter it traces a continuous atmosphere line the length of the card.

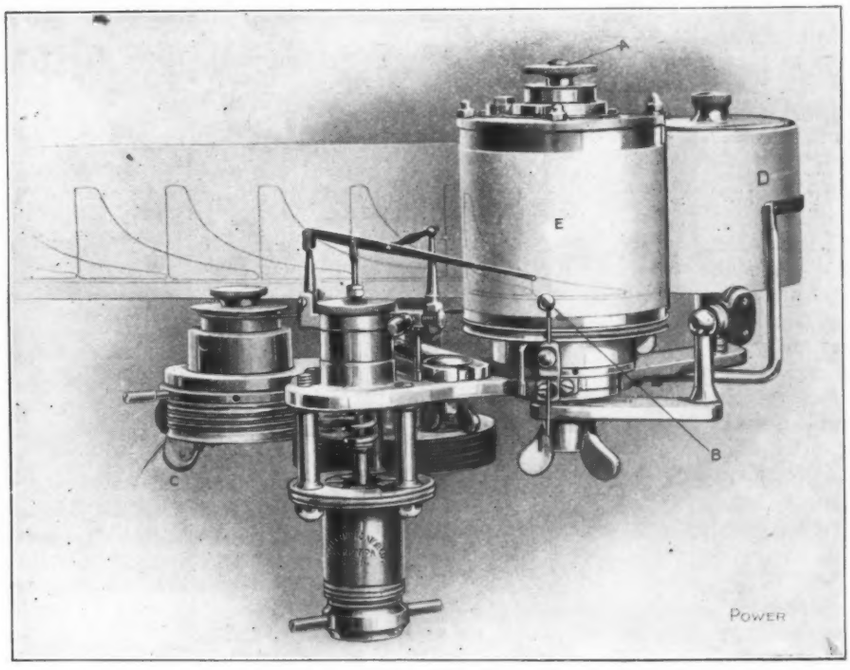
The cord is pulled out to its full length and held by the detent *C*. The cord hook is then attached to some part of the crosshead from which the driving motion is obtained. Releasing the detent *C* starts the indicator. For a continuous card, the nut *A* is screwed down, which sets the paper translating device into action, and a series of diagrams will be traced, as shown in the illustration. This strip of paper can be torn off at any place and the diagrams examined.

A spring and catch hold the tracing pencil against the drum when taking continuous diagrams assuring a uniform pressure on the pencil point.

If a continuous diagram is not desired, the nut *A* is loosened while one diagram is being traced and then tightened while the engine makes two revolutions, which brings an entire new sheet of paper on the tracing cylinder and another complete diagram can be traced by loosening nut *A*. Separate diagrams can thus be taken whenever desired.

The indicator has a spring entirely outside of the cylinder, removed from the high temperature steam, or the cutting action due to wire drawing.

The position of the atmospheric line



TRILL CONTINUOUS CARD INDICATOR

on the drum can be adjusted by turning the small nut on the pencil motion on top of the cylinder.

Each indicator has two cylinders, one having an effective area of ½ sq.in. for low-pressure work, the other an effective area of ¼ sq.in. for high-pressure gas-engine work.

This indicator is manufactured by the Trill Indicator Co., Corry, Penn.

Over the Spillway

An engineer told us the other day that he put Shims under the knock-off block. Anybody here seen Shims?

Why do some correspondents neglect to give their names when writing? We are asked: "Why do my feed pipes clog?" Is this man an engineer or a victim of the "quick-lunch" habit?

"Say, Doran, our frind Gawge Perkins, of N'York, sez that electricity have given wings to ther human moind, an' it's ther moind an' not ther body as does ther business."

"Take it from me, Horan, ther moind is an unsafe thing to hitch yer overall straps on if ye intind to presarve ther peace an' kape yer body in ther background."

Our local police are again in hot water for raiding a pipe layout in "Lefty" Heater's place. Magistrate Feedwater says that for once the "system" is all right, but the cops are too zealous.

An *American Machinist* contributor says he pays for his vacation every year by writing for the technical papers. This is offered as a good "home-made kink" to POWER readers.

Newspaper notoriety has been achieved by an industrial-betterment worker on his return from Europe, where he was a delegate to the recent congress of accident prevention. He states that his son has to study in Germany "to learn things not to be had in America—to study, to be respectful, to be obedient." *Nicht wahr!* In one of Uncle Sam's power plants he would sure learn to be obedient and respectful, no matter how far in the rear his "learning things" straggled.

Berton Braley, story-writer and poet, was once a coal passer.

Nikola Tesla submits a proposition to the New York Board of Education whereby the dull pupil can be made bright and the bright pupil a mental "white way" by day and by night. It is the electric "bath." He would pass through the school-room air a high-frequency current of "millions of volts." The room would thus be "saturated with infinitesimal waves vibrating at great frequency." Nikola seems to have appropriated Jonah's trite remark to the whale: "You can't keep a good man down," or out of the public eye.

Emery Wheel, over to Turner's mill, lost his bearings one day last week and dropped on the floor. The way Em's been cutting up lately made his shopmates cal'late he'd go to pieces sooner or later.

The first arc-control system was installed by one Noah, a marine engineer, in the very earliest stages of its development. It operated continuously for 40 days and nights. At that time, Noah was the greatest living authority on marine propulsion and had the exclusive use of all the water-rights.

Hi Stack has stopped smoking since the Chicago smoke inspectors have got so all-fired particular. Hi asseverates that the one course to travel by is charted by Ringelmann.

An Illinois lighting company voluntarily raised its employees' pay two cents an hour, and the press report naïvely adds that the men were "surprised." Sort of a two-cent stamp of approval, eh what?

"Mirth is God's medicine," said Dr. Holmes. "Everybody ought to be bathing in it." Now turn on the water and let your neighbor hear you "splash." Everybody ought to be doing it.

Con Crete, of C. Ment, Stone & Sand, has floored the whole engine room. Says he's set against folks walking all over him.

Congress has refused permission to dam Duck River, Tennessee. In a manner of speaking, it ducked the bill. We have yet to learn that the irate petitioners have dammed Congress.

NEW PUBLICATIONS

ELEMENTARY MECHANICAL REFRIGERATION. By Fred E. Matthews. McGraw-Hill Book Co., New York City. Cloth; 172 pages, 6x9 in.; 43 illustrations; 24 tables. Price, $2 net.

In this book, addressed to "the busy man at the desk, drawing-board and throttle," the author presents in simple form the principles of refrigeration, approaching the subject from the heating point of view so that the reader by stepping up from a subject more widely known may readily grasp the meaning.

Beginning with an elementary discussion on cold and its production and a few pages on the development of mechanical refrigeration, the author takes up in logical order: commercial systems of refrigeration, including direct expansion, brine circulation, ice-freezing, etc.; the compression and absorption systems; ice-making systems, installation and operation, working pressures, cleaning, determining capacity of refrigerating machines and cold-storage duty.

With the exception of a passing reference to the dense-air process, the book has been confined exclusively to the use of ammonia. Here it is as complete as might well be expected from the limited number of pages. The busy practical man and beginner should find the book a valuable stepping-stone into the subject of refrigeration and obtain some useful hints from the chapters devoted to operation and cleaning.

REFRIGERATION, COLD STORAGE AND ICE MAKING. By A. J. Wallis-Tayler. D. Van Nostrand Co., New York City. Cloth; 655 pages, 6x9 in.; 414 illustrations; tables. Price, $4.50 net.

This book, which was closed by the author in December, 1911, is in its third edition, and, although a number of the plates have been replaced by blocks of more modern machines, a few new cuts added and the text describing the machinery revised, it is incomplete and much of its contents out of date, so far as American practice is concerned.

The introduction gives statistics of the trade in fresh provisions in England from 1891 to 1910. Chapter II deals with the theory of heat, the laws of gases and a classification of refrigerating methods into the five principal heads; liquefaction, vacuum, compression, absorption and cold air. The two systems first mentioned are treated briefly in Chapters III and IV, and the next three chapters, containing 118 pages, are devoted to the compression system.

A good description of the cycle of operation is given, and the balance of Chapter V describes at length and illustrates the ether machines of Perkins, Twining, Harrison and Tellier, Pictet's, Twining, dioxide and Windhausen's carbon-dioxide machines, all of which are out of date, although perhaps of historic interest. In the description of the ammonia compressors in Chapter VI, the old machines and some made by companies out of business for a number of years, have not been eliminated.

Condensers and water coolers are given 22 pages, and Chapter IX deals with the absorption system. Only the older types of machine are mentioned, and nothing is said of the new exhaust steam and combination methods. In the chapter on the cold-air system, references dating back to 1881 indicate that the latest material on the subject has not been incorporated. In Chapter XI, valves and fittings are given some attention, and the subject of the next four chapters, taking 111 pages, is "Refrigeration and Cold Storage." In this space ammonia and brine circulation, ventilation, insulation,

piping, and conveying machinery are covered, and here, too, most of the references date back 20 to 30 years.

"Marine Refrigeration" in Chapter XVI, and "Refrigeration in Dairies" in the chapter following, give strictly English practice, while Chapter XVIII briefly outlines industrial applications in chocolate factories, breweries, etc., and constructional application, such as tunneling and sinking shafts.

Chapter XIX takes up the various methods of ice making in Europe, and as foreign methods are not employed in this country, the descriptive matter can only be of general interest. This does not hold, however, in the chapter following on management and testing of refrigerating machinery, as many good pointers of a practical nature are given and also some space to the interpretation of indicator diagrams. A chapter on cost of working, in which old data of very little value at the present are given, and 14 pages on liquid air complete the book.

Aside from the fact that the book is out of date in many respects, it contains a great deal of valuable matter, and to those interested in foreign practice it is well worth having.

Big Dam for Seattle

A big dam on the Jordan River on Vancouver Island, 40 miles northwest of Victoria, will be built for the British Columbia Electric Ry. Co. The dam will cost about half a million dollars, will be 800 ft. long and 115 ft. deep and be built on the Ambursen type of reinforced-concrete structure.

Men are already at work on the construction and it is expected that the structure will be completed in eight months.

SOCIETY NOTE

The Sixth International Congress for Testing Materials was formally opened on Sept. 2 in the Engineering Societies' Bldg., 29 West Thirty-ninth St., by Robert W. Hunt, of Chicago, president of the American Society for Testing Materials. The proceedings and brief abstracts of discussions will appear in an early issue.

John Fritz's 90th Birthday

John Fritz, who has been ill at his home in South Bethlehem, Penn., for some weeks, passed his ninetieth birthday anniversary recently. He was born Aug. 21, 1822. The past year is marked by the publication of Mr. Fritz's autobiography.

Mr. Fritz said: "The publication of my autobiography before my death is owing to the fact that, against my wishes, these good friends would not wait for it but insisted on having it now. And so I have jotted down the record of my life, and it is given to you as I wrote it. You must not expect fine language nor eloquent periods, but only the honest record of the hardworking life of one who loves his country and his fellowmen, and who has tried to serve both."

OBITUARY

Harris Boardman

The recent death of Harris Boardman, superintendent of the Edison Electric Illuminating Co., Lancaster, Penn., occurred at Atlantic City, N. J.

Luther E. Mansfield

Luther E. Mansfield died at his home in Brooklyn on Aug. 27, aged 84 years. He was a retired manufacturer of elevators and for many years connected with the Brooklyn Electric Elevator Co. of Brooklyn. Mr. Mansfield's wife, Sarah Ann Mills, died six years ago, and he is survived by a son, Earl; a daughter, Florence; two grandchildren, and one great-grandchild.

Herbert W. Spear

Lieut. Herbert W. Spear, chief engineer of the United States revenue cutter "Seminole," died recently at Edgartown, Mass., where he had been on sick leave for some time, owing to heart trouble. He was a native of Quincy, Mass.

Lieut. Spear had several thrilling experiences while in the revenue-cutter service, one of the most notable being when he had to swim ashore from the "Gallatin" in a blinding snowstorm when that vessel was wrecked off the Massachusetts shore in the early nineties.

Warren H. Girvin

On Aug. 16, Warren H. Girvin, formerly manager of the Syracuse (N. Y.) Lighting Co., died at his home in Syracuse, N. Y. He was born in Oneida, N. Y., in 1865 and went to Syracuse about 40 years ago. Starting as a telegraph operator, he became interested in the Bell Telephone Co. and was made manager of the local office, which position he held until 1890, after which he assumed the management of the Syracuse Lighting Co. In 1900 he returned to the telephone business, but ill health compelled him to retire in 1905. A widow, son and daughter survive Mr. Girvin.

Thomas H. Brady

Thomas H. Brady, owner of the Brady Electric Manufacturing Co., New Britain, Conn., died recently at his summer home, Westbrook, Conn. Mr. Brady was one of the earliest pioneers in the manufacture of outside electrical construction material, his first contribution being the well known Brady mast-arm, patented in 1897. His acquaintance in the electric field, especially among those who may be called the old-timers, was very extensive, and his social spirit and interesting stories of the early days of the electric business made him welcome at any gathering. Mr. Brady leaves a wife and ten children.

PERSONAL

J. W. Hungate is the new chief engineer of the power station of the Spokane & Inland Empire R.R., Spokane, Wash.

E. P. Shanks is the chief engineer of the power station of the People's Traction Co., Galesburg, Ill., in place of J. H. Hibbard.

Thomas E. Bryant has succeeded J. T. Maher as chief engineer of the power station of the Richmond & Henrico Ry., Richmond, Va.

E. Brown is the engineer of the power station of the Chicago & Milwaukee Electric R.R., Highwood, Ill. J. F. Shreffler formerly held this position.

N. A. Miner has succeeded J. C. Whitney as chief engineer of the power station of the Springfield & Northeastern Traction Co., Riverton, Ill., a part of the Illinois Traction System.

R. L. Cardiff, formerly chief electrician of the Coast Counties Light & Power Co., Santa Cruz, Calif., is now in charge of the plant, having succeeded C. W. Coleman as general manager.

R. G. Black. formerly superintendent and chief electrician of the Toronto Electric Light Co., Toronto, Ont., who sailed for Europe on Nov. 15, to consult specialists, has returned to Toronto again somewhat improved in health.

L. W. Hench, for the past three years power engineer of the Youngstown Consolidated Gas & Electric Co., has resigned and will become the Youngstown representative of the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Penn.

Robert A. Foresman has been appointed superintendent of motive power of the Des Moines (Iowa) City Ry. For the past six years he was chief engineer of the power plant of the St. Joseph Ry., Light, Heat & Power Co., St. Joseph, Mo. He will be succeeded in St. Joseph by John Elftman, who was assistant engineer of the power station.

Jules de Fischer, chief electrical engineer of the Budapest Local Ry. Co., and Marcell Jellinek, electrical engineer, Budapest, are making a six weeks' visit to the United States, inspecting the suburban and interurban electric-railway systems in the Eastern and Central States. The Budapest Local Ry. is a large suburban and interurban railway system, serving the city of Budapest and neighboring cities and is equipped with the 1200-volt system.

Moments with the Ad. Editor

Is there anything advertised in POWER with which you are not familiar?

Did you ever think of that before?

If so, what did you do?

Were you content to let it be, or were you ready to investigate?

Some of you engineers don't lick enough stamps.

You are backward about sending for samples, booklets and other literature which would make you the wiser, in many cases, and which these advertisers are only too glad to send you.

You've gained most of your knowledge through the hard school of experience, and you've earned it.

But there are a whole lot of little things you can get from hints and data offered you by the advertisers in this paper.

Many large factories are being planned and built, or enlarged, every year for the purpose of manufacturing some *new* specialty or some *new* equipment for *your* very plant.

Then, don't you realize that these manufacturers have to offer you something better and something different or new to get you interested?

The question is—Are *you* keeping in touch with these *new* things?

Are there any new "kinks" offered you that you are not "hep" to?

Our advertisers want you to have all the information available about their particular machines or products, whether you buy now, or a year from now, it matters not when.

It's helpful to them—and to you.

The writer was in a power plant the other day talking to an engineer who has spent 21 years at his profession.

He said he had been a regular subscriber to "Power" for 16 years. Asked if he read the advertising section, his answer was decidedly in the affirmative.

On his desk, (one of his own make, by the way) lay a catalog of a concern that makes a well known lubricator.

On noting that he was not using this lubricator in his plant, he was asked: "How came you to write for this catalog?"

His answer was characteristic of every "result getting" engineer. He wrote for this catalog because the advertiser offered to show him a way to better lubrication, and a way to save considerable money on his cylinder oil. He wanted to know the *how* and the *why*, and he wrote for the particulars.

We know of several instances where engineers have answered advertisements out of as much curiosity as of interest, and they got information and data that was helpful and unexpected. And the advertiser got the order.

Why not take an inventory of yourself today? Run through the advertising pages of "Power" and see if any of these advertisers "has anything" on you.

Are they offering something or offering to *do* something to help your plant conditions that you are inclined to doubt, off-hand, without investigating?

There are local conditions in your plant that do not exist in any other plant, perhaps; *so*, when any of these advertisers spends his good money to tell you how a certain condition can be overcome, why not find out *what* he has got?

Remember this—"Power" is your paper. It's edited for you. Every advertisement you see in "Power" is written direct *to you* and *for you*, by advertisers who recognize the buying influence you have, and that your say can make or break 75 to 90% of the sales that are made in the power plant field.

Don't admit that there are helpful things advertised in "Power" today with which you are not familiar.

Get *all* you can out of "Power" advertising *now*.